

INTESTINAL OBSTRUCTIONS

*A Physiological and Clinical Consideration with
Emphasis on Therapy, Including Description
of Operative Procedures*

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A PHYSIOLOGICAL *and* CLINICAL
CONSIDERATION *with Emphasis on*
THERAPY, *Including* DESCRIPTION of
OPERATIVE PROCEDURES

By

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TO MY WIFE

PREFACE TO SECOND EDITION

THE GENEROUS reception accorded the first edition of this book, published now almost five years ago, prompts the writer to undertake its revision. That book published under the title of *The Therapeutic Problem in Bowel Obstructions*, was an outgrowth of the Samuel D. Gross Prize Award of the Philadelphia Academy of Surgery for 1935, and was published in compliance with stipulations of the Gross Prize.

The present edition is, in many respects, a new book. The difficulty of arrangement of subject matter encountered in the first edition, an occurrence which came about through supplementing the Gross Essay by additional related materials, has been done away with in the revision. The plan of this edition is a more natural one and the scheme employed for discussion of the subject matter permits its presentation under four distinct sections or parts, which are as follows: (1) The Effects of Obstruction, (2) General Diagnostic Considerations in the Recognition of Bowel Obstruction, (3) General Therapeutic Considerations in Its Management, and (4) The Special Obstructions.

It was the writer's intention to employ the chronological or historical method in discussing the experimental aspects of the bowel obstruction problem. It was found, however, that the mechanistic conception of the ill effects of intestinal obstruction developed in the Gross Essay of the first edition, served the writer's purpose best. The skeleton of that presentation has been preserved, therefore.

Special emphasis has been placed on the therapy of intestinal obstruction. In the first edition, considerable space was lent the conservative management of certain types of intestinal obstruction, by suction applied to an indwelling duodenal tube—then, a new form of therapy. In this edition an attempt has been made to secure a more even balance between operative and non-operative forms of treatment. Intestinal intubation with the Miller Abbott tube, a technique developed since the publication of the first edition, is described. After an experience now of more than 10 years with conservative decompression—a method which has exerted, apparently, a material favorable influence upon the mortality of intestinal obstruction, the writer feels that, further general decrease of the risks of obstruction will come about largely through improvements in dealing with obstructed patients surgically. With that consideration in mind, and mindful also of the shortcomings of the suction method, great pains have been taken to attempt to describe, more adequately, satisfactory surgical procedures in the management of intestinal obstruction.

When the surgeon learns to decompress the distended bowel aseptically, at operation, only then will the mortality attending surgical intervention begin to exhibit palpable betterment. The uniformly low mortality rate in the group of cases treated successfully by the indwelling duodenal tube owes this accomplishment undoubtedly, to achieving decompression without peritoneal soiling. When conservative methods are persisted

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in, until the viability of the bowel is threatened or impaired seriously, the risks assumed are pyramided considerably. Elaboration of safe and effectual means, which will permit dealing with the problem of distension, at operation, will make an important contribution to the therapy of intestinal obstruction.

As in the first edition an attempt has been made to integrate clinical and roentgen evidence in the diagnosis of obstruction. Suggestions that diagnosis may be made from x-ray films alone, without the orientation afforded by clinical findings, this writer feels, are out of place. A proper fusion of clinical and roentgen observations constitutes the best basis for sound interpretations and accurate diagnosis.

Everyone is a debtor to his Profession. It has been a pleasant and dutiful task to record, in these pages, the writer's experience with the bowel obstruction problem—representing, in large measure, knowledge gained from others.

Minneapolis, Minnesota

PREFACE TO FIRST EDITION

THIS ESSAY appears in print in compliance with one of the stipulations of the Samuel D. Gross Prize Award. It attempts to set forth in a concise manner the important aspects of the therapeutic problem in obstruction of the bowel as they appear to the writer. It is more concerned with the problem of therapy as it relates to the subject of obstruction of the intestine in the broad sense than with special considerations peculiar to certain types of obstruction. In essence, this essay is a brief digest of the writer's investigations and experience in the field of intestinal obstruction.

The management of bowel obstruction has been the subject of several special treatises in various languages, it has been often a major theme for discussion at surgical congresses and symposia. And rightfully so, for despite conspicuous improvement attending the results of treatment of many acute abdominal lesions, up until quite recently no similar progress could be boasted of in the management of acute intestinal obstruction. It was lamented on every hand that fifty years of abdominal surgery, resplendent with brilliant achievements in many parts, had effected no material reduction in the mortality of bowel obstruction—a satisfactory and adequate explanation appeared to have been found in the testimony of many experimental investigations which indicated the occurrence of abnormal absorption from the lumen of the obstructed bowel—a circumstance permitting inundation of the organism with profound and lethal toxins. Many clinicians were quick to seize upon the toxic factor finding in this refuge some solace for their misgivings and an ample account for their poor results in the treatment of bowel obstruction.

But slender support has been lent to the toxin absorption theory as the important factor in the cause of death in obstruction of the bowel by recent researches. More and more it is becoming increasingly evident that the mechanical factors with which this essay aims in particular to deal are of the greatest consequence. There is much yet to learn concerning the bodily upsets and disturbances which accompany obstruction of the bowel. It is eminently significant and gratifying, however to know that therapy guided by an understanding of the lessons learned in the study and investigation of bowel obstruction has resulted in definite lowering of the mortality of the disease. Successes with the treatment of late cases of obstruction lend their support to the denial that obstruction inevitably carries in its wake the absorption of fatal toxins.

The mortality of the disease is to be sharply differentiated from the mortality of treatment. That the latter has probably not been a negligible factor is to be inferred from the distinctly better results which are being obtained in many quarters by employment of therapeutic measures of proved value. ~~The results of this study indicate that~~ relief of the obstruction by methods which preserve the sterility of the peritoneum inviolate is a consideration of first importance for a successful issue in the treatment of intestinal obstruction. Any operation directed at release of the obstruc-

tion must be accomplished *aseptically*. Escape of obstructed intestinal content at operation is synonymous with failure and death.

In a short essay such as this, it is manifestly impossible to treat of bowel obstruction in all of its phases. In the main, the writer has confined himself largely to those factors which bear most directly upon the therapeutic problem of obstruction. If the publication of this manuscript were to await the correction of all shortcomings and imperfections it undoubtedly would never see the light of day. Some of its weaknesses have been repaired in part through supplementing the essay by additional chapters, in which it has been possible to relate in greater detail some of the more practical aspects of diagnosis and therapy and describe the principal features of special obstructions. Inasmuch as the non-operative treatment of certain obstructions is advised herein, it was deemed essential to recount the deliberations upon which other lesions could be excluded satisfactorily, together with a brief recital of the writer's concept of the fundamental guiding principles, underlying the therapy of the common acute abdominal disorders. The time has come when "acute abdomen" can no longer be considered synonymous with operation. We stand on the brink of a new era in the surgery of acute abdominal afflictions in which surgical exploration will be done less frequently and in which the necessity for operation will be determined largely by what operation can accomplish.

The writer regrets in particular that it has not been possible frequently to discuss many notable contributions in the measure which their importance merits. If this effort which has been the agreeable labor of some leisure hours, aids in any manner in focusing attention upon the significant factors which relate to the therapeutic problem of bowel obstruction, the most sanguine hope of the writer for the essay will have been gratified fully. If the recital of these experiences will lessen in a degree for others some of the difficulties through which the writer has passed in the management of patients with bowel obstruction, its writing will have been justified adequately.

ACKNOWLEDGMENTS

THE STIMULUS for writing this book grew out of collaborative researches carried on in the Experimental Surgical Laboratory over a period of more than fifteen years on various aspects of the bowel obstruction problem. Without the helpful and enthusiastic assistance of the collaborators, who are now more than a score in number, the materials for this volume would not have been available.

It is also a pleasant duty to acknowledge the helpful support which the researches—from which source this book derives its inspiration—have received from the following sources:

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OWEN H. WANGENSTEEN

CONTENTS

PREFACE TO SECOND EDITION	
PREFACE TO FIRST EDITION	--
ACKNOWLEDGMENTS	XI
LIST OF ILLUSTRATIONS	XXII
LIST OF TABLES	XXVII

PART I

INTESTINAL OBSTRUCTIONS

A PHYSIOLOGICAL AND CLINICAL CONSIDERATION WITH EMPHASIS ON THERAPY INCLUDING DESCRIPTION OF OPERATIVE PROCEDURES

INTRODUCTION	3
STATEMENT OF THE PROBLEM	4
CHAPTER I THE EFFECTS OF DISTENSION	8
A The Character and Source of the Distension	8
Source of fluids contributing to distension in obstruction	8
The consequences of fluid and electrolyte losses	10
The nature of fluid and electrolyte losses in obstruction	11
The question of hyperpotassemia	14
Source of gas contributing to distension in obstruction	15
The swallowed air factor	17
How is gas swallowed?	19
Qualitative analysis of gas accumulating in the bowel in obstruction	20
Method	20
Results	21
Comment	24
B The Manifestations of Distension Upon the Bowel Wall	25
How the manner of obstruction influences the effects of obstruction	25
Influence of the site of obstruction upon the effects of distension	25
Length	27
Weight	27
Strength.	27
Breaking strength of small and large intestine in man	28
The intra enteric pressure in bowel obstruction	28
Intra enteric pressure in the obstructed small bowel	29
The intra colonic pressure in obstruction	30
The influence of the ileocecal sphincter and valve	30
The anatomy of the ileocecal sphincter and valve	32
Contractile activity of obstructed bowel	32
Effects of increased intra enteric pressure upon the blood flow to the bowel	33

Effect of constantly sustained pressure	34
Histology of the bowel wall	36
Comment	37
Influence of length of the segment	37
The hydraulic stress factor	38
Neurogenic factor in closed loops	40
C The Systemic Effects of Intestinal Distension	41
D Absorption in Obstruction	44
The avenues of absorption	45
Absorption of substances to which the normal bowel is permeable	45
Absorption of water from the normal and obstructed bowel	45
Absorption of histamine from the obstructed bowel	46
Venous absorption from the obstructed bowel	46
Experiments	46
Results	47
The manner and degree of absorption in obstruction	47
Experiments	47
Lymphatic absorption	49
Experiments	49
Comparison of lymphatic absorption from simple and closed loops and the significance of increased intra enteric pressure	50
The influence of obstruction upon the lymphatic absorption of bacteria	50
Experiments	50
F The Significance of the Blood Loss Factor in Strangulating Obstructions	51
Comment	55
Effect of intravenous injection of peritoneal fluid attending strangulating obstruction	55
Results	56
Influence of arterial and vein ligation on absorption of strychnine	56
The bacteriology of the peritoneal fluid accompanying strangulating obstruction	57
F The Toxemia Question and Bowel Obstruction	57
Experimental data suggesting venous absorption in obstruction	59
G Summary of the Effects of Obstruction	60
Conclusions	63
What are the probable lethal factors in obstruction?	64

PART II

GENERAL DIAGNOSTIC CONSIDERATIONS IN THE RECOGNITION OF BOWEL OBSTRUCTION

CHAPTER II DIAGNOSIS IN ACUTE ABDOMINAL DISORDERS	74
A The Making of a Diagnosis	74
B The History	75
Pain	76
Nausea and vomiting	77

Urination	78
The bowels	78
Menstruation	78
C The Physical Examination	79
General condition	79
The temperature	79
The pulse	80
The blood pressure	80
The examination of the abdomen	80
Inspection—	80
Palpation—	82
Percussion—	84
Auscultation—	85
Rectal and vaginal examination	86
D Special Examinations	87
Gastric intubation	87
Enemas	87
E Laboratory Procedures	88
The urine	88
The blood	89
Roentgenography	89
Method of taking the film	92
CHAPTER III THE RECOGNITION OF OBSTRUCTION	98
A Is the Bowel Obstructed?	98
Pain	98
The significance of intestinal colic	98
The vomiting of bowel obstruction	99
General physical findings	99
Laboratory aids	100
X ray observations—	100
B Where Is the Obstruction?	101
How should the film be taken?	103
C Is the Obstruction Complete or Incomplete?	107
D How Is the Gut Obstructed?	107
E Integration of the Time Element into Obstruction	110
F Identification of the Type of Obstruction	111
G Establishing the Diagnosis	111
H The Differential Diagnosis of Obstruction	112
Simple obstruction	112
Strangulating obstructions	113
Distinguishing simple and strangulating obstructions	114
Strangulating obstruction with little or no evidence of distention	115

PART III

GENERAL THERAPEUTIC CONSIDERATIONS IN THE MANAGEMENT OF ACUTE INTESTINAL OBSTRUCTION

CHAPTER IV GUIDING PRINCIPLES IN THE TREATMENT OF ACUTE ABDOMINAL LESIONS	117
A Abdominal Injuries	117

What viscera are injured?	118
The Treatment of Abdominal injuries	119
Penetrating injuries	119
Blunt Trauma	120
B Hemorrhage	123
C Perforation	124
D Obstructions	124
E Inflammation	125
F Pancreatic Necrosis	128
CHAPTER V ADJUVANT (INDIRECT) MEASURES IN THE TREATMENT OF BOWEL OBSTRUCTION	131
A Saline Solution	131
Sodium chloride balance	132
Status of hydration and water requirements	133
B Blood and Plasma Transfusions	134
C Inhalation of High Concentrations of Oxygen	135
CHAPTER VI DECOMPRESSION BY APPLICATION OF SUCTION TO DUODENAL TUBES IN OBSTRUCTION	138
A Factors Suggesting Use of Conservative Decompression	138
The rationale of conservative decompression	141
The necessity for the use of suction	142
The degree of suction necessary	145
The hydrodynamics of negative pressure applied to rigid and elastic tubes	145
Measures which aid decompression when it does not quickly occur	148
B Indications for the Employment of Decompression by Suction	149
Mechanical obstructions	149
Functional obstructions	151
Other conditions in which the employment of suction is indicated	151
Contraindications to suction	153
C Technique of the Employment of Suction	153
Passing the catheter	154
Additional schemes to intubate the duodenum	156
The apparatus	157
How long is suction to be continued?	160
The Miller Abbott tube and its use	161
Other uses of the Miller-Abbott tube	165
Complications involving the tube	166
The ear marks of successful decompression	166
D Shortcomings of Suction	167
E The Results of Conservative Decompression	167
The after-story of patients with bowel obstruction treated conservatively	168
Lessons learned concerning the so called toxic factor in simple bowel obstruction attending the employment of suction	168
The role of conservative decompression in the prevention of intestinal obstruction	169
Lessons learned about vomiting	170
F Complaints of Patients Relating to the Employment of Suction	170

G Administration of Fluid While Suction Is in Force	172
H History of Use of Duodenal Tube	174
I Rectal Siphonage	174
CHAPTER VII OPERATION IN BOWEL OBSTRUCTION	179
A Surgery, the Mainstay of Therapy	179
Selection of cases for operation	179
General considerations in the selection of operative procedure	181
B Choice of Operative Procedure	181
Simple obstruction	183
C Pre operative Preparation	185
D Selection of Anesthetic	187
E Conduct of the Operation	189
The incision	189
F Locating the Obstruction	192
G Enterostomy	193
Technique of enterostomy	195
The site	195
Tapping the bowel aseptically	197
H Dealing with the Obstructed Colon with Enormous Distension	198
I Manner of Dealing with Strangulated Bowel	198
I Determining Whether the Bowel Is Viable	200
K Exteriorization with Fistula	201
L Dietary Management in High Intestinal Fistula	202
M Protection of Skin	205
N Entero Anastomosis	205
O Attacking the Obstructive Mechanism Directly in Simple Obstructions	206
P Reaction with Primary Anastomosis	206
Q Additional Methods of Dealing with Distension at Operation to Reduce the Risks of Primary Resection	207
Aseptic decompressive suction enterostomy	209
R Partial Enterectomy in an Unobstructed Interval, for Recurrent Obstruction due to Adhesions	211
CHAPTER VIII THE CLOSED ASEPTIC RESECTION	218
A Technique of Oblique End to end Anastomosis	221
B Management of the Mesenteric Border	225
C Dealing with the Epiploic Appendages in Colonic Anastomoses	225
D Obstruction at Gastro jejunal Stomas	227
E Intraperitoneal Implantation of Sulfathiazole about Anastomoses	232
F The Operative Risks of the Closed Anastomosis	234
CHAPTER IX POSTOPERATIVE TREATMENT	237
A Care on Completion of Operation	237
B Care of the Patient on Arrival at the Ward	238
C Shock	238
D Position in Bed	240
E Pulmonary Atelectasis	241
F Prevention of Thrombosis	242
G The Postoperative Administration of Fluid	242
Sodium chloride needs	242

Water requirements	243
The kind of fluid	244
Routes for administration of fluid	244
H Maintenance of Caloric and Nitrogen Balance	245
<i>Intravenous administration of nitrogen</i>	246
Intravenous administration of glucose to maintain caloric balance	248
I Distension	248
J Bowels	249
K Avoidance of Pulmonary Complications	249
L Retention of Urine	250
M Hiccup	250
CHAPTER V THE MORTALITY OF ACUTE INTESTINAL OBSTRUCTION	254
A The Mortality of Bowel Obstruction	254
B Suggestions to Decrease Mortality	257

PART IV

THE SPECIAL OBSTRUCTIONS

CHAPTER VI CONGENITAL ATRESIA OF THE INTESTINE	261
A Pathogenesis	261
Frequency	261
B Theories of Origin	261
C Pathology	262
D Clinical Features	264
E Diagnosis	265
F Differential Diagnosis	266
G Prognosis	267
H Treatment	267
CHAPTER VII IMPERFORATE ANUS	274
A Pathogenesis	274
Frequency	274
B Embryology	274
C Pathology	275
D Clinical Features	278
E Diagnosis	279
F Prognosis	280
G Treatment	281
Technique of proctoplasty	282
H Mortality of Operation	286
I Remote Results	286
CHAPTER VIII INTESTINAL OBSTRUCTION DUE TO TUMORS AND STRICTURES OF THE BOWEL WALL	290
A Benign Tumors	290
B Benign Strictures	290
C Malignant Tumors	293
Carcinoma of the small intestine	294
Pathogenesis	294
Pathology	294
Clinical Features	295
Treatment	297

Carcinoma of the large intestine	298
Pathogenesis	298
Pathology	300
Clinical features	300
Differential diagnosis	302
Treatment	303
Technique of dealing with the neoplasm in the bowel after obstruction has been relieved	306

CHAPTER XIV OBTURATION OBSTRUCTION	316
A Intestinal Obstruction Due to Gallstones	316
Pathogenesis	316
Pathology	317
Clinical Features	317
Diagnosis	318
Differential Diagnosis	319
Treatment	319
Technique of removal of stone	321
Mortality	322
B Intestinal Obstruction Due to Foreign Bodies and Food	322
C Intestinal Obstruction Due to Enteroliths	323
D Intestinal Obstruction Due to Worms (Ascariasis)	325
Clinical Features	325
Treatment	326
E Intestinal Obstruction Due to Meconium in the Newborn	327

CHAPTER XV FECAL OBSTRUCTION OF THE BOWEL (HIRSCHSPRUNG'S DISEASE MEGACOLON, CONGENITAL IDIOPATHIC DILATATION OF THE COLON)	333
A Pathogenesis	333
B Pathology	334
C Clinical Features	335
D Treatment	335

CHAPTER XVI INTESTINAL OBSTRUCTION DUE TO COMPRESSION OF THE BOWEL	340
A Pathogenesis	340
B Pelvic Obstructions (Pregnancy)	340
C Arterioenteric Obstruction	342
D Acute Gastric Dilatation	343

CHAPTER XVII INTESTINAL OBSTRUCTION DUE TO ADHESIONS AND BANDS	347
A Pathogenesis	347
B Pathology	348
C Clinical Features	349
D Differential Diagnosis	349
E Treatment	350
Prevention of adhesions	353

CHAPTER XVIII INTESTINAL OBSTRUCTION DUE TO EXTERNAL HERNIA	358
A Pathogenesis	358
B Pathology	360

Water requirements	243
The kind of fluid	244
Routes for administration of fluid	244
H Maintenance of Caloric and Nitrogen Balance	245
Intravenous administration of nitrogen	246
Intravenous administration of glucose to maintain caloric balance	248
I Distension	248
J Bowels	249
K Avoidance of Pulmonary Complications	249
L Retention of Urine	250
M Hiccup	250
CHAPTER V THE MORTALITY OF ACUTE INTESTINAL OBSTRUCTION	254
A The Mortality of Bowel Obstruction	254
B Suggestions to Decrease Mortality	257

PART II

THE SPECIAL OBSTRUCTIONS

CHAPTER VI CONGENITAL ATRESIA OF THE INTESTINE	261
A Pathogenesis	261
Frequency	261
B Theories of Origin	261
C Pathology	262
D Clinical Features	264
E Diagnosis	265
F Differential Diagnosis	266
G Prognosis	267
H Treatment	267
CHAPTER VII IMPERFORATE ANUS	274
A. Pathogenesis	274
Frequency	274
B Embryology	274
C Pathology	275
D Clinical Features	278
E Diagnosis	279
F Prognosis	280
G Treatment	281
Technique of proctoplasty	282
H Mortality of Operation	286
I Remote Results	286
CHAPTER VIII INTESTINAL OBSTRUCTION DUE TO TUMORS AND STRICTURES OF THE BOWEL WALL	290
A Benign Tumors	290
B Benign Strictures	290
C Malignant Tumors	293
Carcinoma of the small intestine	294
Pathogenesis	294
Pathology	294
Clinical Features	295
Treatment	297

I Treatment	407
K The Blood Loss Factor	411
I Mortality	412
M Postoperative Fever	412
N Non operative Reduction	412
O Recurrent Intussusception	414
CHAPTER XXII ERRORS IN DEVELOPMENT OF THE INTESTINE GIVING RISE TO INTESTINAL OBSTRUCTION (OTHER THAN CONGENITAL STENOSIS)	421
A Anomalies of Rotation Embryology	421
Pathogenesis	423
Clinical features of obstruction occasioned by non rotation	425
Treatment	426
The writer's operation for non rotation	426
B Extrinsic Duodenal Stenosis	428
C Exomphalos (Omphalocele Umbilical Eventration)	430
D Meckel's Diverticulum	430
CHAPTER XXIII INHIBITION ILEUS (PARALYTIC) (Adynamic Ob- struction)	435
A Pathogenesis	435
B Pathology	436
C Clinical Features	437
D Treatment	438
CHAPTER XXIV SPASTIC ILEUS (Dynamic Obstruction)	445
A Pathogenesis	445
B Pathology	446
C Clinical Features	446
D Diagnosis	447
E Treatment	448
CHAPTER XXV INTESTINAL OBSTRUCTION DUE TO VASCULAR CAUSES, MESENTERIC THROMBOSIS AND EMBOLISM	451
A Pathogenesis	451
B Pathology	452
C Clinical Features	452
D Differential Diagnosis	453
E Treatment	454
How much small intestine may be excised safely?	455
INDEX OF AUTHORS	461
INDEX OF SUBJECTS	476

C Clinical Features	360
D Treatment	362
CHAPTER XIX INTESTINAL OBSTRUCTION DUE TO INTERNAL HERNIA	366
A Diaphragmatic Hernia	366
Pathogenesis	366
Pathology	367
Clinical Features	367
Treatment	369
B Intestinal Obstruction Due to Hernia into the Foramen of Winslow	370
Pathogenesis	370
Pathology	371
Clinical Features	371
Treatment	371
C Paraduodenal Hernia (Mesentericoparietal or retromesocolic hernia)	372
Pathogenesis	372
Pathology	372
Clinical Features	374
Treatment	375
D Congenital Hole in the Mesentery	375
E Intersigmoid Hernia	376
F Pericecal Hernia	377
CHAPTER XX VOLVULUS	383
A Pathogenesis	383
Sigmoid Flexure	384
Cecum	385
Small Intestine	386
Stomach	386
B Pathology	387
C Clinical Features	387
Sigmoid Flexure	387
Volvulus of the Small Intestine and Cecum	388
D Differential Diagnosis	389
E Treatment	390
F Mortality	391
CHAPTER XXI INTUSSUSCEPTION	396
A Frequency	396
B Pathology	398
C Types of Intussusception	399
D Manner of Growth	401
E Pathological Changes	401
F Clinical Features	402
Pain	402
Vomiting	402
Blood	403
Tumor	403
G Diagnosis	404
H Chronic Intussusception	405
I Differential Diagnosis of Acute Intussusception	406

FIGURE

PART III

31	Closure of the duodenum in the surgical management of massive hemorrhage from bleeding duodenal ulcer	122
32	Decompression by suction applied to an indwelling duodenal tube in a high grade low ileal obstruction	141
33	Decompression after three hours of suction in a complete jejunal obstruction	144
34	Radiographs and charted course of a patient in whom decompression by suction was effected after fifty-five hours	146
35	Suction apparatus for gastro duodenal siphonage	154
36	Three bottle suction apparatus	155
37	Duodenal tube with multiple perforations and leaded tip	157
38	Enterostomy employed to complement duodenal siphonage because of the appearance of symptoms suggesting strangulation	158
39	Miller Abbott double lumen balloon tipped tube for intestinal intubation	162
40	High grade obstruction relieved by Miller Abbott tube	163
41	Miller Abbott tube in decompressing obstructed bowel	163
42	Use of the Miller-Abbott tube in locating an occult intrinsic obstruction in the bowel	165
43	The angle of inclination of the Eustachian tube in the fetus	171
44	Intestinal suture pack	187
45	Abdominal incisions for operations upon the gastro intestinal canal	190
46	Closure of an abdominal incision	191
47a	Method of emptying a distended loop of small bowel preparatory to enterostomy	194
47b	Alternate mode of emptying a distended loop of small intestine	194
48	Technique of enterostomy	195
49	Method of scoring catheter to fasten it in the bowel	196
50	Technique of decompressing the distended colon	199
51	Manner of dealing with an intestinal fistula when exteriorization is done for gangrenous small bowel	202
52	MacNaughton's scheme for carrying away intestinal secretions from an intestinal fistula	203
53	Operative methods of achieving decompression of the distended small intestine	209
54	Techniques suggested by Halsted in the making of an end to end anastomosis	218
55	Method suggested by Halsted to accomplish primary resection and anastomosis by the closed method in the pelvic colon	219
56	A scheme devised to circumvent the difficulty of the mesenteric angle in end to end anastomosis of the small bowel	220
57	Aseptic (closed) oblique end to end anastomosis in the small intestine	222
58	Solution of the difficulty of the mesenteric angle	223
59	Mode of preparing the colon at operation for an oblique end to end anastomosis	224
60	Resection clamps for the closed anastomosis	224

LIST OF ILLUSTRATIONS

FIGURE

PART I

1	High intestinal obstruction	10
2	Ileal obstruction	10
3	The distribution of fluid in the body	12
4	Composition of plasma	12
5	The acid and basic ions of plasma	13
6	Schematic presentation of the effect of loss of the various gastro intestinal secretions	14
7	The distension factor in simple obstruction	17
8	The intestines in a dog 57 days after complete ileal obstruction and esophagostomy	19
9	Check valve mechanism of lips of ileocecal valve and sphincter	31
10	Activity of bowel proximal and distal to obstruction	32
11	Schematic summary of effects of sustained intraluminal pressure in closed loops (see table 12)	34
12	The role of the ileocecal valve and sphincter in acute obstruction of the colon	39
13	Intraintestinal air insufflation and its effects on venous pressure	42
14	Types of experimental strangulating obstruction	52
15	Blood volume losses and length of survival following various types of strangulating obstruction	53

PART II

16	The contour of the abdomen in intraperitoneal tumor and ascites	81
17	Shifting dullness in the presence of free peritoneal fluid	85
18	X ray films of the abdomen in peritonitis	90
19	X ray film taken in the erect posture to demonstrate the presence of pneumoperitoneum	91
20	Rupture of the retroperitoneal duodenum	92
21	Visible and palpable coils of bowel in stricture of the small intestine	101
22	Tension perforation of cecum due to carcinomatous stricture of ascending colon	102
23	Obstruction of the colon	104
24	Roentgenogram in acute obstruction due to carcinoma of the ileocecal valve and sphincter	105
25	On first glance this film would suggest a mechanical obstruction of the small intestine, etc	106
26	Complete obstruction of the small intestine	108
27	Incomplete obstruction of the small intestine	108
28	The stasis-ray in chronic obstruction of the small intestine	109
29	The anatomic situation of the loops of small intestine as described by Mall	110
30	Roentgen films of air inflated segment of intestine	112

FIGURE	
92 Carcinoma of the transverse colon	298
93 Large primary carcinoma of the stomach involving transverse colon	299
94 Partial colectomy for malignancy of right colon	302
95 The most frequent location of obstructions which give rise to intestinal perforations in simple bowel occlusion	303
96 Perforations of the descending colon due to a carcinomatous stricture of the pelvic colon	304
97 Subtotal colectomy for polyposis	305
98 Primary subtotal colectomy for chronic ulcerative colitis	306
99 Subtotal colectomy for multiple lesions in the colon	307
100 Gallstone obstruction	318
101 Air and barium in the bile ducts	319
102 Technique of aseptic operation for removal of gallstone from intestine	320
103 Photograph of gallstone causing obstruction	321
104 Retention of barium in diverticula of the small intestine	324
105 Excised segment of small intestine with sacculations	324
106 Ascarides causing acute intestinal obstruction	326
107 Demonstration of ascariasis by roentgen examination	327
108 Megacolon in Hirschsprung's disease	334
109 Sigmoid flexure in a boy of three years with congenital megacolon (Hirschsprung's disease)	334
110 Intestinal obstruction during pregnancy	341
111 Spontaneous closure of colostomy after decompression for acute colonic obstruction	342
112 Acute dilatation of the stomach	343
113 Adhesions demonstrated by inflation of carbon dioxide into the peritoneal cavity	349
114 Method of inverting a small gangrenous area in the gut wall (so called Summer's stitch)	351
115 Pneumoperitoneum after enterolysis to prevent adhesion formation between anterior abdominal wall and the intestines	354
116 The incidence of various types of intestinal obstruction	359
117 The presence of bowel in a strangulated femoral hernia	362
118 Diaphragmatic hernia with symptoms of acute intestinal obstruction	367
119 Repair of pleuro peritoneal hiatus hernia in diaphragm	368
120 Left paraduodenal hernia	373
121 Right paraduodenal hernia	374
122 The potential for volvulus in the colon	383
123 Volvulus of the sigmoid flexure	384
124 Volvulus of cecum	385
125 Enterocystoma of jejunum causing volvulus	386
126 Configuration of the sigmoid flexure in recurrent volvulus	388
127 Exteriorization operation (Bloch Paul Mikulicz) for volvulus of the colon	390
128 The various types of intussusception	398
129 Retrograde intussusception of jejunum through gastrojejunostomy stoma	399
130 Demonstration of intussusception by roentgen examination	405

FIGURE

61	Aseptic (closed) oblique end to end anastomosis after excision of carcinoma of pelvic colon	226
62	Technical steps in lateral anastomosis of the small intestine, employing the v. Petz suturing apparatus	228
63	Use of v. Petz suturing apparatus in intestinal surgery	229
64	Reversal of mesentery of one segment of the bowel in oblique end to end anastomosis as suggested by Dennis	230
65	The resultant stoma in end to end anastomosis	230
66	Mechanism of obstruction at the efferent outlet after gastro-jejunal anastomoses	231
67	Venous obliteration attending intraluminal pressure at various levels in the bowel	231
68	Forked catheter employed to prevent obstruction in the proximal jejunal loop after gastrojejunal anastomoses	232
69	Mode of transfer of patients who have undergone long and difficult operations from the operating room	237
70	Use of shock frame in recovery period	239
71	Manner of obtaining bed-side weights of patients after operation	243
72	Photograph of hospital record	247
73	Use of Boothby-I overlace mask for the administration of high concentrations of oxygen	251
74	The mortality from acute intestinal obstruction at the Massachusetts General Hospital	256

PART II

75	Multiple areas of constriction in atresia of the intestine of a newborn	263
76	Duodenal atresia	265
77	Congenital duodenal stenosis	268
78	Method to increase the diameter of the lumen of the bowel to facilitate anastomosis in intestinal atresia	269
79	Gastro jejunostomy for duodenal atresia	270
80	Frequency of the various types of imperforate anus	276
81	Imperforate anus with termination of the rectum in the posterior commissure of the vagina	277
82	Fecal impaction in the rectum and pelvic colon in imperforate anus with termination of the rectum in the vagina	278
83	Method of demonstrating the extent of imperforation	279
84	Skia gram of an infant with atresia of the colon	280
85	Operative correction of imperforation of the anal canal and rectum	283
86	Varco glass rectal dilator for treatment of stenosis	285
87	The distribution of benign and malignant tumors in the small intestine	291
88	Stricture formation after devascularization of the small intestine	292
89	Multiple lympho-sarcomas of the small intestine	295
90	Enlargement of the abdomen in stricture of the small intestine	296
91	Primary resection of the small intestine for a malignant stricture causing obstruction	297

LIST OF TABLES

PAGE

0

16

18

21

22

22

22

23

23

23

24

35

41

43

133

138 140

143

173

175

180

187

203

204

204

255

262

275

275

276

286

286

286

293

FIGURE

131	Operative reduction of intussusception	408
132	Exteriorization of the terminal ileum for irreducible and gangrenous intussusception	410
133	Reduction of intussusception by barium in an infant	414
134	Stages in the development and rotation of the intestine	422
135	Non rotation of the intestine and the writer's operation to correct the defect	424
136	Röntgen films of non rotation of the intestine before and after operation	427
137	<i>Recurrent and chronic obstruction due to congenital duodenal stenosis</i>	428
138	Ladd's operation for extrinsic duodenal stenosis due to compression bands	429
139	Intestinal obstruction due to Meckel's diverticulum	430
140	J II Murphy's case of spastic ileum of the small intestine	445
141	Enormous distension of the colon in spastic ileum	447
142	Exteriorization in continuity of bowel of questioned viability	454
143	Large fibromyxosarcoma necessitating excision of a long segment of small intestine	455

INTESTINAL OBSTRUCTIONS

*A Physiological and Clinical Consideration with
Emphasis on Therapy, Including Description
of Operative Procedures*

34	Incidence of Obstruction of the Colon	300
35	Types and Incidence of Obstruction Causing Ascariasis	325
36	Mortality of Obstruction Due to Ascariasis	326
37	Incidence of the Various Types of Hernias in Strangulation	358
38	The Incidence of Hernia and Strangulation	358
39	Age Incidence of Volvulus of the Sigmoid Flexure	385
40	Incidence of the Various Types of Intussusception	400
41	Time of Appearance of Melena in Intussusception	403
42	Operative Mortality of Intussusception	411
43	The Causes of Mesenteric Vascular Occlusion	452
44	Sites of Mesenteric Vascular Occlusion	453

PART I

INTESTINAL OBSTRUCTIONS

INTRODUCTION

It was undoubtedly the observation of Hartwell and Hoguet (1912), indicating that the lives of dogs, with high intestinal obstruction, could be prolonged considerably with the subcutaneous administration of saline solution, that intensified the interest of experimental workers more sharply in the bowel obstruction problem. With clarification of the mystery, that veiled the true nature of the toxic death of dogs with high duodenal obstruction, by Gamble and his co workers (1925), the mechanism by which saline solution exerted this protection became apparent. Failure of saline solution to afford the same character of protection to animals with ileal obstructions focused attention upon the great importance of the mechanical effects of distension upon the bowel wall. It was Amussat (1839) who promulgated the thesis of absorption of an abnormal toxin from the obstructed bowel which caused death. This century old concept of the lethal factor in bowel obstruction can not be put aside lightly. Yet critical review of the available experimental work, that has been done upon the problem serves to emphasize the significant inter relationship of intra enteric tension, viability of the gut wall and the permeability factor. Loss of viability of the bowel wall, opens up a new avenue of absorption, the transperitoneal migration of noxious agents from the bowel lumen.

This is essentially the important lesson that experimentation, during the past fifteen years has taught. Moreover, it is a precept which has most significant connotations for the clinician who cares for patients, with intestinal distension. Long reaches of obstructed bowel, in which distension maintains a low but constant and steady increase of intraluminal pressure constitute the most frequent and difficult problem of therapy.

After a decade's use of saline solution in the management of patients with acute intestinal obstruction following demonstration of its protective properties in high obstructions, McIver found no tangible evidence that the hospital mortality had been influenced favorably thereby. Moreover with increasing appreciation and recognition of the great importance of the mechanical factors in the production of the ill consequences of obstruction and with development of satisfactory methods to combat distension a general lessening of the mortality of obstruction is becoming apparent. McKittrick and Sarris (1940), in reviewing the experience of the Massachusetts General Hospital with the bowel obstruction problem, since the report of McIver (1934) state that for the first time in 40 years, a decline in the mortality of acute intestinal obstruction in that institution has become evident. Similar reports have

1

sorption) is not significantly altered unless the viability of the bowel wall is impaired

The effect of sustained increases in intraluminal tension upon portal, femoral and inferior vena caval venous pressures will be pointed out. It will be shown that large intestinal distensions impede the return of venous blood from the lower extremities with resultant increase of venous pressure and delay in circulation time. How this segregating effect of distension upon the vascular system may occasion the loss of effective circulating blood volume will be described.

It will be indicated further that, absorption by way of the mesenteric vessels is diminished under conditions of obstruction while lymphatic absorption appears increased. It will be shown in strangulating obstruction that an important item in the lethal factor, apart from eventual death of the imprisoned intestinal loop, is loss of blood into the infarcted segment.

With reference to timely recognition of bowel obstruction, it will be shown that upon establishment of the presence or absence of intestinal colic the diagnosis rests largely. It will be indicated that, whereas vomiting is a prominent feature of mechanical obstruction of the small intestine frequently obstruction of the colon despite enormous distension, may be unassociated with vomiting. It will be pointed out that feculent vomiting does not occur with uncomplicated obstruction of the large bowel but is frequently a sequel to high grade obstructions of the small intestine. It will be shown that the interpretation of an x ray film of the abdomen correlated with the clinical findings enables one to determine readily, usually whether obstruction is present, whether it is complete or incomplete, whether it concerns the small intestine or colon, and if in the small intestine whether the obstruction lies in the upper, middle, or lower third of the gut and whether the obstruction is simple or strangulating in character. It will be indicated that while these characters of obstruction may be defined readily, it is difficult, not infrequently, to ascertain the exact nature of a given obstruction without recourse to operation. The varieties of obstruction giving rise to such difficulty of identification will be discussed briefly.

In treating of the remedial agents of value in the relief of bowel obstruction, it will be shown that saline solution aids in combating dehydration but is without specific influence except in very high obstructions that transfusion of blood and plasma are of considerable value in strangulating obstructions where the blood loss into the infarcted segment may be great, also in high grade simple obstruction owing to diminution of effective circulating blood volume through the segregating influence of distension that transfusion of plasma may be a useful expedient. It will be demonstrated that simple mechanical obstructions, and particularly when not complete may be relieved frequently by suction applied to an intubating duodenal tube without recourse to operation. How frequent use of suction after abdominal operation has done away largely with the early postoperative obstructions will be recounted, to

emanated from a number of clinics, in many places, and lend encouragement to the hope that the forbidding mortality of the disorder will cease to exist

In the volume on *Vital Statistics of the United States for 1937* published by the Bureau of the Census in 1939, it is to be noted that appendicitis, the most important single cause of death amongst acute abdominal disorders, took a toll of 15 340 lives. From intestinal obstruction alone 7 780 lost their lives. Hernia took a toll of 5,331 lives, of which number, undoubtedly, a large proportion died of obstruction. Further, of the 69 335 deaths due to malignancy of the digestive tract, 23,872 concerned the intestines, of this number 15,978 died of malignancies of the small and large intestine and 7 894 from malignancies of the rectum and anus. Intestinal obstruction is often the immediate cause of death in intestinal neoplasms.

The true importance of obstruction as a lethal factor is obviously difficult to assess with reasonable accuracy. For distension and obstruction are terminal events in many abdominal tragedies. Certain it is, that intestinal distension relates itself so intimately to a number of clinical conditions, as to constitute a therapeutic problem of major importance.

Statement of the Problem

The general problem of bowel obstruction appears to fall quite naturally into four categories: (1) elucidation of the effects of obstruction and particularly, the resultant consequences of distension upon the bowel wall, (2) definition of criteria by which timely recognition of bowel obstruction may be made, (3) critical appraisal of the remedial agents directed at the relief of obstruction, (4) special consideration of the various clinical types of obstruction.

It is proposed to treat of the bowel obstruction problem with these particular items in mind. Insofar, as intestinal distension is intertwined so inseparably with the manifestations of a number of abdominal disorders, it is deemed advisable to discuss briefly the general fundamental diagnostic and therapeutic considerations, which underlie a number of acute abdominal catastrophes, not primarily obstructive in nature.

With reference to the effects of distension, it is proposed to relate how the bowel becomes distended, what the elements are that contribute to the existence of distension and what their sources are. The consequences of fluid losses in bowel obstruction will be reviewed. The effects of distension upon the bowel will be traced and it will be indicated that such results are largely the result of increased intra-enteric pressure. The extent of these pressures in the experimental animal as well as in clinical cases of obstruction of both the small and large intestine will be related. The significance of the ileocecal valve and sphincter in the development of high intra-colonic pressure will be shown. There will be indicated the effects of obstruction upon the length, weight, strength and histology of the bowel wall, how the blood supply to the intestine is influenced by increased intra-enteric pressure and, how in turn it influences the viability of the gut. It will be shown that the permeability (transperitoneal ab-

the bowel has been impaired seriously. Yet, too many patients are lost by surgical blunders. This writer believes that the time is at hand, when concentration of the care of patients, presenting the effects of bowel obstruction, in the hands of a few persons in large hospitals, well oriented in all the therapeutic ramifications of the problem, will demonstrate effectually the validity of the premise, that *how* a procedure is carried out, is equally as important as *what* is done. The truth of this statement has been shown amply in the risks of resections of the stomach and colon. To be sure all the factors in a patient with acute intestinal obstruction are not controlled as readily, as in an operation of election. Distension itself, constitutes a major surgical problem at operation frequently. Surgical techniques must be devised which will permit dealing adequately and safely with distension at operation. The patient whose distension remains unrelieved by attempts at accomplishing decompression by conservative means constitutes a serious problem for the surgeon. The surgeon must learn to decompress the distended bowel at operation, in order that he may deal effectually in certain instances with the obstructing mechanism. When the surgeon masters the art of dealing with the item of distension at operation without visible traces of soiling, preserving the sterility of the peritoneum another important milestone will be reached in the reduction of the mortality of intestinal obstruction. The planned procedure guided by full knowledge of the physiologic principles involved and executed with infinite care and exacting precision will tell. When the *mortality of treatment* is reduced to a minimum the unavoidable mortality, the only real measure of the *mortality of obstruction* per se, will become apparent.

limitations and shortcomings, indications and contraindications of the method will be defined and the mechanics of its operation rationalized. How the use of the balloon tipped Miller Abbott tube may pyramid usefulness of non operative decompression will be described.

It will be shown that inhalation of high concentrations of oxygen, as described by Fine and his associates (1936), when used in conjunction with constant suction, applied to an indwelling duodenal tube, is an adjunct measure of value in augmenting the absorption of nitrogen from the distended bowel. Demonstration of the potential hazards of high concentrations of oxygen when administered uninterruptedly to normal dogs by Paine and his associates (1941), suggests that caution be observed, however, with administration over protracted periods of time.

It will be indicated that, whereas suction makes the necessity for operative intervention less urgent in a number of obstructions, operation continues still the most important agency in the relief of mechanical obstructions. Those obstructions which need immediate operation will be enumerated. How the character of the obstruction influences the choice of operative procedure will be discussed. The technical features of acceptable and satisfactory operative procedures directed at the relief of obstruction will be defined.

Finally, the results of treatment will be recounted, first with reference to accomplishments with the problem as a whole, subsequently, under the special captions of the particular problems peculiar to each variety of obstruction. Achievement with the special obstructions will be discussed, in turn.

More general recognition and appreciation of the effects of obstruction, better comprehension of the diagnostic criteria which contribute to recognition of the presence of obstruction and a more discerning appraisal of the worthwhile remedial agents in the relief of obstruction—all of these have had a part in the encouraging note that is becoming more palpably evident in the therapeutic problem of acute intestinal obstruction.

The very grave nature of the difficulties which hedge about the management of patients, presenting strangulating obstruction with considerable distension—the chief stumbling block and the present most important cause of death—are well known to all who have wrestled with the problem. One important source of difficulty is constituted by the absence of absolutely reliable differential criteria to distinguish simple and strangulating obstructions. Considered and careful adjudication of the problem presented by potential strangulating obstruction in the light of available differential criteria, alert attention to the great significance of blood and plasma losses in strangulating obstruction, intelligent and discriminating use of conservative decompressive measures—all of these have an important role in contributing to the lowering of the mortality presented in patients with strangulating obstruction.

In the immediate years which lie ahead, the factor which appears to afford greatest promise in dealing with the formidable and serious problem of strangulating obstructions is improvement in the execution of surgical maneuvers. Surgical relief must come, of course before the viability of

of an obstructed loop Molnar (1909) has shown that section of the extrinsic nerves of the bowel results in a continuous secretory activity (paralytic secretion) and that the intravenous injection of meat extracts intensifies the activity of intestinal glands

For a number of reasons it would appear, therefore, that the alimentary fluids may be increased considerably in obstruction

TABLE I RATES OF TURN OVER OF WATER BY VARIOUS ORGANS IN A 70 KILO HUMAN INDIVIDUAL IN CUBIC CENTIMETERS PER 24 HOURS (Adolph)

Organs	Minimum	Liberal
Salivary glands	500	1 500
Stomach	1 000	2 400
Intestinal wall	700	3 000
Pancreas	700	1 000
Liver (bile)	100	400
Lymph	700	1 500
Total recovered by body	3 700	9 800
Kidneys	600	2 000
Colon (feces)	50	200
Skin (insensible loss)	350	700
Sweat glands	50	4 000
Mammary glands	0	900
*Total lost from body	1 050	7 800
Total turn-over	4 750	17 600

Adolph estimates loss by vaporization from lungs at 36 per cent of the extra renal losses

Doubt has been thrown upon the observations just referred to, in which it was indicated that the alimentary fluids secreted in obstruction exceed the normal by the experiments of Montgomery and Swindt (1934) In a study of the "Effect of simple duodenal obstruction upon the combined gastric, pancreatic biliary, and duodenal secretions" and the "Influence of closed intestinal loop strangulation on volume of the combined secretions" these authors found no evidence of stimulation to excessive secretion on the contrary they found the fluid accumulations slightly less than in normal controls

The degree to which fluid accumulations contribute to distension in obstruction depends essentially on the location and the degree of the obstruction which in turn determine the fluid lost by vomiting The higher the obstruction the more readily are the intestinal fluids vomited Even in low obstructions in the small intestine, the vomiting of fluid may be great, but the residual accumulation of fluid with the effects of distension upon a long stretch of bowel wall will be greater than in high obstructions It should be stated here that the loss of fluid through the agency of vomiting in obstructions of the colon is negligible Such patients present evidence of gastric retention rarely, as will be shown subsequently

CHAPTER I

THE EFFECTS OF DISTENSION

A THE CHARACTER AND SOURCE OF THE DISTENSION

THE content of an obstructed bowel consists of fluid and gas which are present in varying amounts. The extent to which each of these components contributes to the distension in any given instance is difficult of prediction. On the whole, however, the longer the duration of the obstruction, the greater is the fluid content. Acute obstructions are largely gaseous in character.

Source of Fluids Contributing to Distension in Obstruction

The fluids which are dumped normally into the alimentary canal are known to be large in amount. From information garnered through a number of sources, Rowntree calculated that, approximately 7,000 cubic centimeters of fluid reached the bowel each day through the activity of glands, which pour their secretions into the upper reaches of the alimentary tube. The sources and amounts of these are (1) saliva, 1,500 cubic centimeters, (2) gastric juice, 2,000-3,000 cubic centimeters, (3) bile, 300-500 cubic centimeters, (4) pancreatic juice, 500-800 cubic centimeters, and (5) succus entericus, 3,000 cubic centimeters. Dragstedt and his associates (1931) have indicated that this amount may be even greater. In an adult of average size, having a plasma volume of 3,500 cubic centimeters, Gamble estimates the total daily volume of digestive juices secreted to approximate 8,200 cubic centimeters. Adolph (1933) gives the following amounts of fluids recoverable from various glands, organs, and sources in the human body. Minimal and liberal estimates of fluids in each instance are given in Table 1.

Under conditions of obstruction, these alimentary fluids appear to be increased in amount. The Dragstedts (1922) observed an increased excretion of gastric juice, pancreatic juice, and bile following the intravenous injection of obstructed loop content into other dogs. They postulated that, owing to increased intravisceral tension in obstruction, abnormal absorption of some of this fluid occurred, which in turn exerted a secretagogue effect on fluid secretion into the bowel. Ivy and his associates (1927) noted a similar but less marked effect on the secretion of gastric juice in dogs when the pylorus was obstructed. Kim (1933) found that similar increase in the secretion of gastric juice attended the injection of histamine and believes therefore that, the absorption of a histamine like substance in obstruction accounts for the increased fluid secretion. The effects of mechanical stimulation alone are not to be overlooked. Gliniski (1891) found that irritating the mucosa of the intestine with cotton pledgets resulted in an increased watery secretion. Herrin and Meek (1933) observed that intestinal distension alone resulted in considerable increase in the secretion

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ters Kilgore and Bollman (1926) found that, the typical blood chemical changes attending experimental high intestinal obstruction occurred also in gastric and duodenal fistula and that saline solution was of value in averting their occurrence as it was in experimental bowel obstruction. The observations were confirmed by Dragstedt and Ellis (1931) and Morton and Pearce (1931).

A number of investigators foremost among whom were Gamble and his associates McIver and Ross (1925), were able to show that the cause of these blood chemical alterations viz, elevation of the nonprotein blood nitrogen, decrease in blood chlorides, and an increased combining power of the blood for carbon dioxide, was the loss of fluid and electrolytes from the stomach and upper reaches of the bowel. They were also able to show that the reason saline solution proved so effectual in avoiding the occurrence of these changes in the blood as well as in improving the condition of animals with high obstruction was that saline solution serves as a satisfactory substitute for the fluid and sodium and chloride ions lost by vomiting. Other variants of sodium chloride when administered with adequate amount of water did not exhibit the virtues of saline solution in this regard. Thus the mystery of how saline solution afforded dogs with duodenal or high jejunal obstruction was solved. Loss of substances essential to life was the lethal factor, not absorption of a noxious toxin.

In low obstructions these chemical alterations in the blood are observed infrequently, undoubtedly because the amount of essential electrolytes and fluid lost by vomiting is less. As will be indicated later, the absorption of fluid from the gut in distension is decreased, nevertheless, enough absorption must occur to obviate the occurrence of these changes in the blood. It has been demonstrated adequately also in both the experimental animal as well as on patients with clinical obstruction that the liberal administration of saline solution fails to elicit the favorable influence noted when it is given in high obstruction. Neither could it be expected reasonably that the administration of saline solution would affect favorably the issue in strangulating obstruction. A number of experimental undertakings attest this fact.

The Nature of Fluid and Electrolyte Losses in Obstruction

The sources of the body fluids are shown in Fig. 3. It is to be noted that intra cellular fluid constitutes the larger fraction. When fluid is lost from the body by vomiting as in high obstruction the blood plasma is first drawn upon with ensuant concentration of the plasma. The blood, in turn, is replenished from the mobile interstitial or intercellular fluid compartment. Loss of this fluid gives rise to the clinical evidences of dehydration. The intra cellular fluid compartment is spared largely in this withdrawal.

The differences in the electrolyte and protein constitution of sea water, plasma, interstitial and cell fluid are shown in Fig. 4. It is to be noted that sodium is the principal cation of both plasma and interstitial fluid, while potassium is the chief cation of cell fluid. The chloride ion is the

The Consequences of Fluid and Electrolyte Losses

The brilliant researches of the past two decades have elucidated quite completely the significance of fluid losses, especially in high obstruction. The role of saline solution in prolonging the lives of dogs with experimental high obstruction initiated the examinations which served to elucidate this aspect of the problem. At first it was believed that saline solution was so efficacious in this particular because it detoxified and neutralized a toxin



FIG 1—High intestinal obstruction. Until demonstration of the efficacy of water and saline solution in prolonging the lives of dogs with this type of obstruction it was believed that death was due to toxic absorption. Adequate replacement therapy obviates occurrence of oliguria, azotemia, hypochloremia, and alkalosis which attend this type of obstruction. Alkalosis is even more likely to attend pyloric occlusion than duodenal or jejunal obstruction for loss of hydrochloric acid without loss of alkaline bile or pancreatic juice leads more readily to an increase of the bicarbonate ion in the plasma (Arch Surg 22 658 1931)



FIG 2—Ileal obstruction. It is this type of obstruction which is responsible largely for continued belief in the toxic absorption theory. The mechanistic conception of the ill effects of obstruction to be developed in this chapter explains quite satisfactorily the sequelae which attend protracted distension of the lower reaches of the obstructed bowel. The old axiom that the high obstructions are the more serious is obsolete. Low obstructions are far more serious. Replacement therapy corrects the situation largely in high obstructions; in low obstructions effective decompression alone can save the situation (Arch Surg 22 658 1931)

which was otherwise absorbed (Haden and Orr, 1923). It was indicated soon, however, by a number of studies that the virtue of saline solution lay largely in its capacity to substitute adequately for the fluids lost by vomiting. Foster and Hausler (1924) observed that following temporary administration of saline solution it could be discontinued, and the animals survived just as long. This observation was confirmed by Gatch, Trusler and Ayres (1927) and by Wangenstein and Chunn (1928). Jenkins (1929, 1932), White and Fender (1930), Armour (1931) and Pearse (1931) confirmed this observation of Foster and Hausler in various ways. They found that attending duodenal or high jejunal obstructions, if saline solution or the vomitus and other nutritive materials were fed into the jejunal loop beyond the obstruction, long periods of survival were the rule. Wal-

main electrolyte in the acid column for both plasma and interstitial fluid, while phosphate is the principal anion of cell fluid. The most conspicuous difference between plasma and inter cellular fluid is the low protein content of the latter.

The electrolyte composition of the various gastrointestinal secretions is shown in Fig 5. It will be observed that the total electrolyte composition is, in each instance, approximately the same as in blood plasma. In the loss of gastric juice attending the vomiting of pyloric obstruction, it is clear that there will be a larger loss in the chloride ion than in the

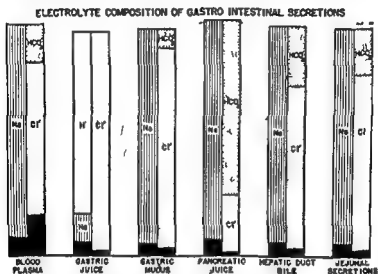


FIG 5—The acid and basic ions of plasma and the gastro intestinal secretions. The total electrolyte content is largely the same as in plasma. The effect upon the pH from the loss of any of the gastro intestinal secretions can be predicted from a knowledge of the electrolyte pattern of each secretion (see Fig 6) (Gamble J I. Harvard Medical School Syllabus 1939)

sodium cation in consequence of which an alkalosis develops with an increase in plasma bicarbonate. Accompanying the loss of sodium and chloride ions in the vomitus a lowering of the plasma chlorides occurs and incident to the dehydration oliguria ensues with consequent retention of non protein nitrogen in the blood. When large quantities of saline solution are given to repair the loss of fluid and electrolytes, the deficit of sodium is made up before the more extensive loss of chlorides is replenished and the excess sodium is excreted in the urine to re establish the normal balance.

From Figs 5 and 6 it is to be deduced that loss of bile and pancreatic juice, will withdraw sodium from the plasma more extensively than the chloride ion. Inasmuch as the pH of the intestinal content in the upper reaches of the jejunum is not unlike that of plasma, the withdrawal of base and acid ions attending vomiting of obstruction at this level will be

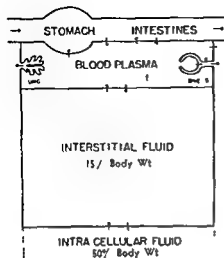


FIG 3—The distribution of fluid in the body. Interchange between plasma and the interstitial fluid spaces is free. The interstitial fluid compartment reflects directly the status of hydration of the body. Dehydration causes an hydremia, plethora is accompanied by accumulation of fluid in the interstitial spaces (Gamble J L Harvard Medical School Syllabus 1939)

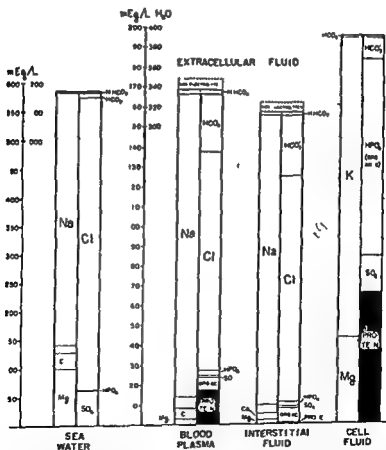


FIG 4—Composition of plasma, interstitial and cell fluid. The similarity between plasma and interstitial fluid is striking, save for the greater protein content of plasma. The Na ion predominates in extracellular fluid, the K ion in intracellular fluid (Gamble J L Harvard Medical School Syllabus 1939)

cortical extract is, undoubtedly, a worthwhile expedient in many states, in which capillary permeability is increased. When such increased capillary permeability is due to transperitoneal migration of bacteria, administration of cortical extract is probably a futile gesture.

Source of Gas Contributing to Distension in Obstruction

The three possible sources of gaseous distension of the obstructed gut are (1) formation of gas as a result of digestive processes, (2) diffusion of blood gases into the intestinal lumen, and (3) passage of swallowed atmospheric air into the intestine. The gases commonly present in intestinal meteorism are nitrogen, oxygen, carbon dioxide, hydrogen, methane and hydrogen sulfide, the proportions being subject to considerable variation.

During the ordinary processes of digestion, considerable carbon dioxide may form as a result of an intermixture of acid gastric juice and the alkaline pancreatic and biliary secretions. Bunge (1905) states that as much as six liters may arise from this source. It is believed also that considerable carbon dioxide may result from the fermentation of sugars and cellulose lower in the bowel. Schwartz (1909) decomposed cellulose at 38° Centigrade. One hundred grams yielded 19.5 liters of carbon dioxide, 7.5 liters of methane and 4 liters of hydrogen. This indicates the enormous amount of gas which may result from the action of bacteria on cellulose. The amount of gas formed normally in the gut as a result of the putrefactive action of bacteria on protein is considerably less than that which results from the fermentative action of bacteria on carbohydrates.

The walls of the intestine are permeable to gases and an active interchange takes place with the blood gases, tending to keep the gases on the two sides of the intestinal mucosa in equilibrium. McIver, Redfield and Benedict (1926) observed that when atmospheric air is placed in the cat's stomach, carbon dioxide enters from the blood until its concentration equals that in the blood. When air containing a high percentage of carbon dioxide is injected into the stomach, carbon dioxide diffuses out of the stomach into the blood. Such active replacement occurs, however, in any degree only with readily diffusible gases. Nitrogen is absorbed very slowly and exhibits only minimal replacement by carbon dioxide and oxygen. McIver, Benedict, and Cline (1926) have calculated the absorptive capacity for the common gases found in the gastro-intestinal tract. In an hour's time when these gases were introduced into a loop of cat's intestine 25 centimeters in length, they found that 160 cubic centimeters of carbon dioxide was absorbed, 69 cubic centimeters of hydrogen sulfide, 176 cubic centimeters of oxygen, 7.5 cubic centimeters of hydrogen, 5 cubic centimeters of methane, and 1.25 cubic centimeters of nitrogen. After injecting atmospheric air into the lumen of the intestine its volume was observed to diminish during the first and second hours because of absorption of oxygen. After the oxygen tension in the bowel had reached that on the other side of the intestinal epithelium, only 4 cubic centimeters dis-

about equal. Whereas the effects of dehydration will accompany such obstructions with oliguria and nitrogen retention, alkalosis due to upsets in the ionic balance is not so likely to occur as in pyloric obstruction. In diarrhea attending lesions of the ileum and colon, base loss predominates usually over loss of the acid ion with resultant acidosis (Fig 6).

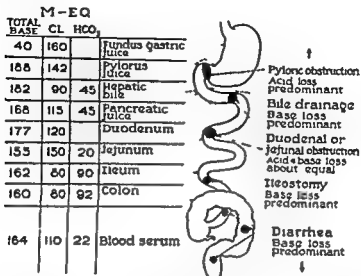


FIG 6—Schematic presentation of the effect of loss of the various gastrointestinal secretions upon the acid base equilibrium of the blood (Coller and Maddock Surg Gynec & Obst 70:345 1940)

The Question of Hyperpotassemia

Reference should be made here to the observations of Cutler and Pijoan (1937) and Scudder and his associates (1937-1938) relating to elevation of the blood potassium levels in obstruction. Accompanying fistulas high in the gastrointestinal canal and intestinal obstructions, Scudder and his associates noted an average increase of 100 per cent in the whole blood potassium levels normal values averaging about 25 milligrams per cent. They believe this hyperpotassemia may constitute a likely important factor in the lethal issue of obstruction. They noted too, that administration of adrenal cortical extract may depress the elevated blood potassium levels.

This concept of the importance of potassium as a lethal factor in intestinal obstruction is not shared by many experimental workers. Bisgard and his associates (1938) and Greenwood, Haist and Taylor (1940) failed to substantiate the contention that potassium was a factor in the cause of death in obstruction. In a group of patients with acute obstruction, Falconer, Osterberg and Borgen (1939) noted a tendency for decrease rather than increase in blood potassium values. The writer shares the latter opinion and is not convinced that potassium plays any important role in the lethal issue of intestinal obstruction. The administration of adrenal

The Swallowed Air Factor

Inasmuch, however, as these closed loops excluded the greater portion of the juices dumped into the intestinal canal and, in consequence, did not duplicate accurately the conditions present in obstruction, it was believed that more exact information could be gained concerning the role played by swallowed air in the gaseous distension of obstruction by excluding the possibility of swallowing air. This was done in the following manner (Wangensteen and Rea, 1939). The cervical esophagus of dogs was transected in the neck, in two stages, and both ends were brought out to

Distension Factor In Simple Obstruction

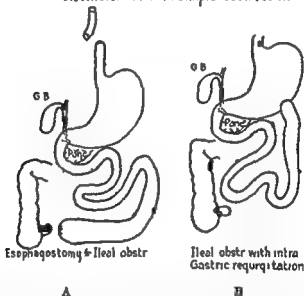


FIG 7—The distension factor in simple obstruction. A Effect of esophagostomy on ileal obstruction. Large dogs with exclusion of swallowed air by esophagostomy may live a long time and fail to develop distension (See Fig 8 and Table III Wangensteen and Rea Surgery 5:327 1939). B Anastomosis of the severed terminal ileum to the stomach. The average survival in 11 dogs with this procedure was 19.9 days—the longest 56 days. From the vantage point of the stomach regurgitant vomiting which empties the terminal reaches of the ileum may occur precluding distension with its damaging effects upon the bowel wall (Wangensteen and Leven Arch Surg 22:658 1931).

the skin. It was learned soon that, the distal end of the esophagus had to be inverted completely to obviate swallowing of air. The mechanism of the swallowing of air will be discussed subsequently. Dogs in which the cervical esophagus had been thus transected, presenting a fistula of the oral end were fed by a stomach tube through the distal end until the wound in the neck was well healed. The dogs prepared best for final operation were fed for a period of about a month's time with liberal quantities of the Scott-Ivy pabulum (See page 203). Then at the same operation the distal end of the cervical esophagus was closed, the gut was

appeared in another five-hour period. Fine and his associates (1935, 1936) have elaborated upon this occurrence and have suggested the inhalation of high concentrations of oxygen as a therapeutic measure in gaseous distension in the intestine, subcutaneous emphysema and other states. This suggestion will be discussed at greater length later.

Kantor (1919) states that gas in the stomach is atmospheric air. In a study of postoperative gaseous distension, McIver and his associates found that the gas consisted largely of swallowed air as modified by oxygen replacement by carbon dioxide from the blood. They suggested frequent removal of swallowed air, as a measure of value, in relieving postoperative intestinal distension. They observed in cats, following the estab-

TABLE II—A GAS AND FLUID ACCUMULATION IN SIMPLE ILEAL OBSTRUCTION

Experiment	Obstruction	Time in days	Gas in cc	Fluid in cc
1	Lower ileum	5	350	350
2	Lower ileum	3	80	80
3	Lower ileum	4	160	180
4	Lower ileum	14	525	590
5	Lower ileum	9	525	900

B CLOSED-LOOP OBSTRUCTION

No of dogs	Site	Average length of gut (cm)	Average No. hrs.	Average No. cc gas	Average No. cc fluid
20	Lower ileum	57.8	82.1	15.0	91
11	Upper jejunum	32.0	31.0	68.5	40

lishment of experimental peritonitis, that when the pylorus was ligated, the stomach filled with gas, but there was no distension of the intestine beyond.

In the distension attending mechanical obstructions, however, McIver (1934) states in his monograph on *Intestinal Obstruction* that, decomposition of intestinal contents is probably the most important contributing cause to the distension. The occasional amazing results obtained following the employment of suction applied to an intubing duodenal tube in decompressing instances of mechanical obstruction of adhesive origin in which gaseous distension was considerable, suggested that these gaseous distensions were probably also brought about largely by swallowed air, whose transit through the gut was interrupted by the mechanical block. Substantial support for this contention was obtained in noting that in a series of twenty-five dogs in which simple obstruction was established in the lower ileum, an average accumulation of 328 cubic centimeters of gas and 420 cubic centimeters of fluid was found in the proximal gut of the dogs, whereas in a series of animals with closed intestinal loops, the amounts of fluid and gas collecting in the loops were found to be considerably less as indicated in the accompanying table.

obstructed by severing it at the site chosen for obstruction after stripping the tract above of its content. These dogs were then given daily 1,500 cubic centimeters of mammalian Ringer's solution subcutaneously. A few of the last dogs in the series were transfused a few times with blood from other dogs in an attempt to increase the plasma proteins which were lowered considerably by the long period of starvation. To the final dog in the series whose survival was longest vitamins B₁ and C were given subcutaneously each day during the last three weeks of life.

Results—The results are shown in Table III. It is to be noted that the average survival was 35.2 days. The longest was 57 days. Three dogs survived for 40 days or longer. With few exceptions, the amount of gas and fluid found in the gut at autopsy was not great. The exclusion of swallowed air permits the closed loop of esophagus, stomach and small intestine to reabsorb the greater portion of the digestive juices dumped into the gut. In Fig. 8 it is apparent that the bowel wall is thickened. The residual content of the obstructed bowel was surprisingly small. The longest period of survival in the controls was considerably shorter averaging about 5 days.



FIG. 8—The intestines in a dog 57 days after complete ileal obstruction and esophagostomy. There was essentially a closed loop of esophagus, stomach and small intestine allowing no opportunity for vomiting. There was 100 c.c. of gas and 125 c.c. of fluid in the bowel at autopsy (see Dog 11 Table 3). The hypertrophy of the musculature of the intestinal coils is apparent (Wangenstein and Res. Surgery 5:377 1939).

How Is Gas Swallowed?

It has been stated already that when the cervical esophagus of dogs was transected as long as the distal end remained open considerable air was still swallowed. This would indicate that the swallowing of air is connected intimately with respiration and would suggest that the negative intrathoracic pressure is largely responsible for its occurrence.

A somewhat similar situation exists in the instance of a baby nursing a bottle. He applies suction to the nipple and a slight negative pressure is established in the bottle, which in turn causes the rush of air and displaces the milk. The baby does not actually apply enough suction to draw the milk out. If the bottle were a closed system and the ingress of air was prevented the exertion of a thousand pounds negative pressure per square inch would not bring out more than a few drops of milk. Unless the walls of the glass bottle were actually sucked in by the force applied the milk could not be evacuated unless the entry of air was allowed.

TABLE III ESOPHAGOSTOMY AND ILEAL OBSTRUCTION (WANGENSTEEN & REA SURGERY 5 327 1939)

Operation	Dog No	Initial Weight (kg)	Saline Solution (cc)	Survival in Days	Gas (cc)	Fluid (cc)	Weight at Death (kg)	Remarks
Esophagostomy + feeding for 1 month then closure of the distal esophageal opening and terminal ileal obstruction + saline solution	1	24.0	1 500	19	100	150	16.5	Dogs 1-7 showed no distention of the gut except for segment 15 to 20 cm proximal to ileal obstruction
	2	20.0	1 500	20	150	50	16.0	
	3	17.5	1 500	32	0	100	12.0	
	4	26.0	1 500	40	50	50	13.2	Dog 4 received 3 transfusions of citrated blood 300 cc each Total plasma protein just before death 4.5 gm %
	5	15.9	1 500	29	0	300	12.5	
	6	17.0	1 500	45	50	60	11.5	
	7	19.5	1 500	34	0	90	10.0	Slight distention
	8	18.0	1 500	33	175	150	13.5	
	9	15.0	1 500	33	600	800	9.5	Died with a volvulus gut markedly distended
	10	20.0	1 500	45	1 000	350	14.5	Stomach and jejunum are contracted received 4 transfusions of citrated blood 300 cc each after ileal obstruction
	11	18.3	1 500	57	100	125	12.5	Ileum was distended and contained 500 gm of semisolid fecal material this dog received a total of 5 transfusions of citrated blood 300 cc each after the ileal obstruction just before the animal was sacrificed plasma protein 4.4 gm % plasma chlorides 676 mg % and nonprotein nitrogen 60.6 mg %
Average survival				35.2				

* Too small to be measured accurately

directly from the intestine into sample tubes. Since the unoperated clinical cases were being decompressed by continuous duodenal suction, the gas sample was obtained by connecting the inlet tube directly to the suction apparatus by a three way stop cock. In order to exclude the factor of atmospheric air in the duodenal tube, samples were collected after the suction had been in operation for a while.

Results

The results are indicated in the accompanying Tables IV to VI. In thirteen dogs, the terminal ileum was severed and the ends inverted. The survival period, the amount of fluid and gaseous content obtained in each instance together with the gas analyses appear in Table IV.

In Table V are indicated the results observed in a group of 8 dogs in which a preliminary cervical fistula for diversion of swallowed air had been established, followed by obstruction of the terminal ileum.

Similar determinations were made in a group with closed loop obstructions of the small intestine, in which the continuity of the remaining gut was re-established. The results of the analysis appear in Table VI.

Determinations were made upon gas accumulating in the pelvic colon of two groups of dogs. In one, simple obstruction was established by severing and inverting the ends of the gut, in the other, a preliminary esophagostomy to obviate the swallowing of air was done. In the latter group, it is quite apparent that the exclusion of swallowed air does not reduce so successfully the amount of gas in the bowel as it did in obstruction of the small bowel when a similar procedure was done.

TABLE IV — QUANTITATIVE ANALYSIS OF GASEOUS ACCUMULATIONS IN SIMPLE ILEAL OBSTRUCTION

Dog No	Wt lb	Duration days	Fluid con- tent cc	Gaseous content							Volatile basic group %
				Amount cc	CO ₂ %	O ₂ %	N ₂ %	CH ₄ %	H ₂ %	H ₂ S %	
1	55	■	150	100	—	—	—	—	—	—	2 0 1 5 8 7 4 2
2	50	■	—	—	4 7	10 0	65 0	0	0	4 3	
3	42	3	300	150	6 2	1 5	71 0	0	0	7 9	
4	48	3	290	200	12 7	1 1	60 0	0	0	14 0	
5	42	3	150	220	12 0	0 7	70 0	0	0	2 0	
6	46	3	220	290	9 3	1 0	74 0	0	0	0 9	
7	44	■	235	320	9 1	0 5	70 0	0	0	4 3	
8	55	■	1196	325	13 1	1 8	73 6	0	0	9 4	
9	36	■	400	200	11 5	0 9	79 4	0	0	6 5	
10	34	7	200	300	8 8	2 1	66 0	0	0	13 2	
11	48	3	210	225	24 2	0 3	53 0	0	3	17 9	
12	32	6	750	250							
13	43	3	420	430	15 0	1 5	23 0	0	5	45 1	
Average			373	235							
Minimum			150	100							
Maximum			1196	430							

Dead

The order of magnitude of the force which causes the suction of air down the esophagus is not great, but when it is realized that this same small negative pressure counteracts the elasticity of the lung, which tends to collapse it, the effect of a slightly superior force can be understood. A pressure of 760 millimeters of mercury is exerted on the external chest wall and is counterbalanced by an equal force coming down the trachea in the inspired air. A differential pressure of a few millimeters of mercury serves to keep the lung expanded, a force representing an advantage of only $\frac{1}{2}$ to 1 per cent of the major forces acting.

What circumstances other than negative intrapleural pressure favor the swallowing of air are not apparent. Whether patients after abdominal operations swallow more air than normally remains to be established. The action of the superior constrictor muscle of the esophagus probably normally interferes with the passage of air down into the stomach. When a nasal catheter is passed into the pharynx for the insufflation of oxygen into the lungs, it is observed that when the distal end of the catheter lies at the lower end of the oropharynx, relatively small quantities of oxygen go into the stomach, when, however, the end of the catheter is passed somewhat beyond the oropharynx, practically all the oxygen may pass into the stomach.

Qualitative Analysis of Gas Accumulating in the Bowel in Obstruction

McIver and his associates (1926) have made determinations upon the gas aspirated from the stomach after operations, which they found to be largely atmospheric air with some displacement of oxygen by carbon dioxide. No determinations have been made in instances of mechanical obstruction. With the object in mind of determining in so far as possible the source of gas accumulating in the bowel, qualitative analyses were made by Hibbard and Wangenstein (1934) in various types of experimental obstruction. Analyses have been made also upon gas aspirated with a duodenal tube in instances of mechanical obstruction as well as upon samples obtained at operation.

Method—The United States Bureau of Mines apparatus was employed in making the analyses and the aid of a qualified gas chemist enlisted. Carbon dioxide was determined by absorption in 30 per cent potassium hydroxide, oxygen in alkaline pyrogallol, hydrogen sulfide in arsenous chloride, and the volatile basic group was absorbed in a known acid and titrated with a known alkali. Hydrogen and the saturated hydrocarbons were determined by the explosive method.

In the animal experiments samples of gas were drawn over mercury into specially made gas tubes while the animals were under ether. The intestine was ligated over the tip of the inlet tube, after the mercury had been forced to the top. By lowering the leveling bottle so as to produce gentle suction, with the aid of a simultaneous stripping process applied to the intestine, in the direction of the inlet tube, the entire volume of gas was drawn into the gas tube. By this maneuver the dead space as a source of error was eliminated satisfactorily.

In the clinical case operated upon the gas was drawn over mercury

TABLE VIII—THE VALUE OF THE GASEOUS CONTENT OF BOWEL AFTER SIGMOID OBSTRUCTION WITH ESOPHAGOSTOMY

Dog No	Wt lb	Duration days	Fluid content cc	Gaseous content						
				Amount cc	CO ₂ %	O ₂ %	N ₂ %	CH ₄ %	H ₂ %	H ₂ S %
1	44	3	150	160	10.9	1.4	63.2	—	12.4	10.1
2	40	3	120	450	18.4	0.5	58.8	0.6	4.2	12.6
3	30	3	220	310	12.2	1.4	73.4	2.8	1.6	8.6

TABLE IX—COMPOSITION OF GAS IN CLINICAL CASES OF SMALL BOWEL DISTENSION (MAN)

No	Diagnosis	X ray findings	Method of obtaining gas	Composition of gas						Volatile base group—
				N %	O %	CO %	H %	CH %	H ₂ %	
1	Mechanical obstruction of ileum	Marked distension of small bowel	Aspiration at operation	60.0	3.0	9.4	0	0	14.0	13.6
2	Mechanical obstruction of ileum	Marked distension of small bowel	Nasal suction	70.0	10.0	9.0	0	0	8.8	5.2
3	Mechanical obstruction	Distension of the small bowel	Aspiration at operation	9.0	9.8	1.0	0	0	10.0	—

TABLE X—NATURE OF GAS IN CLINICAL CASES OF INHIBITION ILEUS (Paralytic)

No	Diagnosis	X ray findings	Method of obtaining gas	Composition of gas					
				N %	O %	CO %	H %	CH %	H ₂ %
1	Diffuse peritonitis	Distension of small and large bowel	Aspiration half hour postmortem	74.2	9.2	7.7	1.2	—	7.7
2	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	71.6	4.4	10.6	6.6	—	6.2
3	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	64.6	8.0	11.8	6.3	1.0	8.4
4	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	80.4	10.0	5.6	0.3	0	3.7

Determinations were made in three cases of mechanical obstruction of the small intestine, four cases of peritonitis with established distension, and in four cases of mechanical obstruction of the colon. In two of this

TABLE V—QUANTITATIVE ANALYSIS OF GASEOUS ACCUMULATIONS IN SIMPLE ILEAL OBSTRUCTION WITH ESOPHAGOSTOMY

Dog No	Wt lb	Duration days	Fluid content cc	Gaseous content						
				Amount cc	CO ₂ %	O ₂ %	N ₂ %	CH ₄ %	H ₂ %	H ₂ %
1	36	8	250	110	12.8	1.1	76.3	0	0	9.8
2	34	3	240	140	9.0	3.2	85.0	0	0	3.1
3	41	3	300	40	9.5	0.4	73.4	0	0.2	8.0
4	43	3	250	100	12.0	5.7	76.2	0	0	6.1
5	28	3	225	160	—	—	—	—	—	—
6	45	3	100	60	12.8	0.9	71.6	0.3	0.4	14.4
Average			227	101						
Minimum			100	40						
Maximum			300	160						

TABLE VI—THE GASEOUS CONTENT OF CLOSED LOOP OBSTRUCTION OF SMALL INTESTINE

Dog No	Wt lb	Duration days	Fluid content cc	Gaseous content							Volatile basic group %
				Amount cc	CO ₂ %	O ₂ %	N ₂ %	CH ₄ %	H ₂ %	H ₂ S %	
1	36	2	80	90	—	—	—	—	—	—	—
2	42	2	150	70	4.5	12.3	87	—	—	—	—
3	40	3	225	83	8.3	2.4	74	—	—	12.8	1.6
4	42	3	1050	40	10.0	4.0	—	—	—	3.0	trace
5	30	5	130	10	—	—	—	—	—	—	—
6	44	8	200	100	—	—	—	—	—	—	—
7	38	3	600	40	5.1	2.8	51	0	0	15.3	—
8	46	dead 3	—	—	18.0	1.0	11	0.1	3.2	62.7	—
9	52	dead 3	—	—	13.0	1.8	37	0	2.3	24.2	3.2
10	26	dead 4	350	20	—	—	—	—	—	—	—

TABLE VII—VALUE OF GASEOUS CONTENT OF BOWEL AFTER OBSTRUCTION OF SIGMOID COLON

Dog No	Wt lb	Duration days	Fluid content cc	Gaseous content						
				Amount cc	CO ₂ %	O ₂ %	N ₂ %	CH ₄ %	H ₂ %	H ₂ S %
1	50	8	650	385	6.5	1.2	80.0	2.6	0	6.7
2	47	3	100	215	10.8	1.4	80.6	1.6	0	5.6
3	39	3	110	375	13.0	0.8	80.1	—	1	4.1

TABLE VIII.—THE VALUE OF THE GASEOUS CONTENT OF BOWEL AFTER SIGMOID OBSTRUCTION WITH ESOPHAGOSTOMY

Dog No	Wt lb	Duration days	Fluid content cc	Gaseous content						
				Amount cc	CO ₂ %	O ₂ %	N ₂ %	CH ₄ %	H ₂ %	H ₂ S %
1	44	3	150	165	11.9	1.4	63.2	—	12.4	10.1
2	10	3	125	450	18.4	0.5	58.8	0.6	4.2	12.6
3	30	3	220	310	12.2	1.4	73.4	2.8	1.0	8.6

TABLE IX.—COMPOSITION OF GAS IN CLINICAL CASES OF SMALL BOWEL DISTENSION (MAN)

No	Diagnosis	X-ray findings	Method of obtaining gas	Composition of gas						Volatile basic group—
				N %	O %	CO %	H ₂ %	CH ₄ %	H ₂ %	
1	Mechanical obstruction of ileum	Marked distension of small bowel	Aspiration at operation	60.0	3.0	9.4	0	0	14.0	13.6
	Mechanical obstruction of ileum	Marked distension of small bowel	Nasal suction	70.0	10.0	9.0	0	0	5.8	5.2
3	Mechanical obstruction	Distension of the small bowel	A puncture at operation	79.0	2.9	8.1	0	0	10.0	—

TABLE X.—NATURE OF GAS IN CLINICAL CASES OF INHIBITION ILEUS (Paralytic)

No	Diagnosis	X-ray findings	Method of obtaining gas	Composition of gas					
				N %	O %	CO %	H ₂ %	CH ₄ %	H ₂ %
1	Diffuse peritonitis	Distension of small and large bowel	A puncture half hour postmortem	4.2	9	7.7	1.2	—	7.7
2	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	72.6	4.4	10.4	6.6	—	6.2
3	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	64.6	8.0	11.8	6.3	2.0	8.4
4	Diffuse peritonitis	Distension of small and large bowel	Nasal suction	80.4	10.0	5.6	0.3	0	3

Determinations were made in three cases of mechanical obstruction of the small intestine four cases of peritonitis with established distension and in four cases of mechanical obstruction of the colon. In two of this

latter group, the gas was obtained from the upper reaches of the gastrointestinal tract by suction applied to a duodenal tube, in the two others, by aspiration after the establishment of colostomy. The results are indicated in Tables IV, V, and VI.

Comment

In the striking difference, in the greater amount of gas present in the terminal ileal obstructions, as contrasted with the amount present where the same procedure was done accompanied by a fistula of the cervical esophagus, as well as in closed loops of the small intestine, the significance of swallowed increments of air in the genesis of intestinal distension is apparent.

The gas present in the closed loops and in those instances in which the swallowed air factor had been excluded, must have arisen by fermentation

TABLE VI—THE GASEOUS CONTENT IN CLINICAL CASES OF LARGE BOWEL OBSTRUCTION

No	Diagnosis	X ray findings	Method of obtaining gas	Composition of gas					
				N %	O %	CO %	H %	CH %	H ₂ S %
1	Carcinoma of rectum	Distension of the large bowel	Nasal suction	76.4	17.0	3.4	0.8	0	9.8
2	Carcinoma of the splenic flexure	Distension of the large bowel	Nasal suction	77.2	13.2	7.2	0	0	2.4
3	Carcinoma of the rectum	Distension of the large bowel	Aspiration of colostomy loop	74.0	1.9	8.4	4.0	2.6	10.2
4	Carcinoma of the rectum	Distension of the large bowel	Aspiration of colostomy loop	69.0	3.4	11.0	8.0	—	8.2

or putrefaction in the gut or must have been brought there from the blood stream. The high per cent of nitrogen in the gas of these cases was at first somewhat of a surprise, but when the high tension of the small amount of gaseous nitrogen (570 millimeters of mercury) in the blood is recalled, the diffusion of nitrogen into the gut under the circumstances mentioned is understandable. As a matter of fact, that could be its only source, for free nitrogen gas is not formed in the intestinal canal. The nitrogen has undoubtedly displaced gas such as carbon dioxide or hydrogen sulphide, which diffuse readily through the bowel wall. It was observed as the obstructions progressed in duration that the amount of carbon dioxide, hydrogen sulphide, and volatile basic group of gases (ammonia, methyl amine, and tertiary amines) increased (Hibbard 1936). The oxygen present was always low.

In animals dead when the gas determinations were made, the amount of hydrogen sulphide present was greatly increased as is indicated in Table VI. The increase in hydrogen sulphide, in these instances, as well as in the terminal obstructions where this figure was also high is probably due

to an increase in protein putrefaction. The amounts of hydrogen sulphide as well as ammonia present in the gut, either as gas or in solution, were found to be non toxic when injected into closed intestinal loops as well as into the intestinal canals of normal dogs. As is well known these gases are extremely toxic, but in the amounts present in obstruction they are detoxified apparently in the process of passing through the bowel wall.

It may be concluded then that, about 68 per cent of gas in the intestine in obstruction has its origin in swallowed air, 32 per cent forms within the body. Of this latter amount, as determined by exclusion of the swallowed air factor in the closed loop series and the high nitrogen content about 70 per cent originated by diffusion of blood gases and especially nitrogen into the bowel lumen, the remaining 30 per cent originated within the obstructed loop.

II THE MANIFESTATIONS OF DISTENSION UPON THE BOWEL WALL

How the Manner of Obstruction Influences the Effects of Obstruction

In order to establish a satisfactory basis for the discussion to follow, it is necessary to relate a few facts which have come largely to be recognized generally concerning the influence of the manner and the site upon the effects of obstruction. There are essentially two varieties of obstruction: (1) simple obstruction in which the continuity of the bowel alone is blocked, and (2) strangulating obstructions, which exhibit in addition to interruption of intestinal continuity, compromise of the blood supply. The latter group because of the arrest of venous outflow from the bowel wall manifests more quickly than do instances of simple obstruction evidences of damage to the bowel wall. Another factor the loss of blood is introduced also and will be described in more detail later. Distension *per se* may imitate at least in part some of the effects of strangulating types of obstruction.

Influence of the Site of Obstruction Upon the Effects of Distension

In man observation indicates and in the dog experiment affirms the impression that the site of the obstruction has an important bearing upon the effects of obstruction. A dog with a complete simple obstruction of the duodenum below the entrance of the pancreatic ducts may with satisfactory replacement by saline solution of the fluids and electrolytes lost by vomiting be kept alive for three to four weeks without disturbance of mineral or nitrogen metabolism. If saline solution were not administered death would occur in three or four days with characteristic metabolic disturbances namely oliguria and finally anuria with consequent azotemia, hypochloremia and alkalosis. Similarly a patient with obstruction of the efferent loop of the jejunum, leading away from the stomach after gastro jejunostomy or gastric resection may with the administration of an adequate amount of saline solution tolerate without serious threat to life the loss of these digestive juices for a comparatively long period of time (14 to 21 days).

In low ileal obstruction in which vomiting fails to empty the lower

latter group, the gas was obtained from the upper reaches of the gastrointestinal tract by suction applied to a duodenal tube, in the two others, by aspiration after the establishment of colostomy. The results are indicated in Tables IX, X, and XI.

Comment

In the striking difference, in the greater amount of gas present in the terminal ileal obstructions, as contrasted with the amount present where the same procedure was done accompanied by a fistula of the cervical esophagus, as well as in closed loops of the small intestine, the significance of swallowed increments of air in the genesis of intestinal distension is apparent.

The gas present in the closed loops and in those instances in which the swallowed air factor had been excluded, must have arisen by fermentation

TABLE XI—THE GASEOUS CONTENT IN CLINICAL CASES OF LARGE BOWEL OBSTRUCTION

No	Diagnosis	X ray findings	Method of obtaining gas	Composition of gas					
				N %	O %	CO %	H %	CH %	H ₂ S %
1	Carcinoma of rectum	Distension of the large bowel	Nasal suction	76.4	17.0	3.4	0.8	0	2.8
2	Carcinoma of the splenic flexure	Distension of the large bowel	Nasal suction	77.2	13.2	7.2	0	0	2.4
3	Carcinoma of the rectum	Distension of the large bowel	Aspiration of colostomy loop	74.0	1.2	8.4	4.0	2.6	10.2
4	Carcinoma of the rectum	Distension of the large bowel	Aspiration of colostomy loop	69.0	3.4	11.0	8.0	—	8.2

or putrefaction in the gut or must have been brought there from the blood stream. The high per cent of nitrogen in the gas of the 4 cases was at first somewhat of a surprise, but when the high tension of the small amount of gaseous nitrogen (570 millimeters of mercury) in the blood is recalled, the diffusion of nitrogen into the gut under the circumstances mentioned is understandable. As a matter of fact, that could be its only source, for free nitrogen gas is not formed in the intestinal canal. The nitrogen has undoubtedly displaced gas such as carbon dioxide or hydrogen sulphide, which diffuse readily through the bowel wall. It was observed as the obstructions progressed in duration that the amount of carbon dioxide, hydrogen sulphide, and volatile basic group of gases (ammonia, methylamine, and tertiary amines) increased (Hibbard 1936). The oxygen present was always low.

In animals dead when the gas determinations were made, the amount of hydrogen sulphide present was greatly increased as is indicated in Table VI. The increase in hydrogen sulphide, in these instances, as well as in the terminal obstructions where this figure was also high is probably due

Length—Whereas, the anatomical length of the intestine is considerable, the physiologic length, as van der Reis and Schembra (1926) have shown, is considerably less. In instances of fistula in the terminal ileum, a catheter of 6 to 9 feet in length was found to negotiate the entire length of the small bowel. The bowel reefs itself upon the tube, making it possible for a much shorter tube to extend through a considerably greater length of bowel. A Miller-Abbott tube, which is 11 feet in length, may pass readily throughout the entire length of the alimentary canal.

When the bowel is distended, contraction of the longitudinal muscle results frequently in shortening of the bowel length. In order to measure the extent of this process in obstruction, ligatures, which could be subsequently readily identified, were measured off at 12 inch intervals along the mesenteric border above the site of obstruction.

Sperling (1938) observed quite uniform shortening of the bowel attending acute obstructions. Placing lead shot along the bowel wall, Bellis (1939) was unable to confirm in similar experiments carried out subsequently that, shortening attended obstruction uniformly. In chronic obstructions, lengthening of the bowel is not unusual.

Weight—A large number of determinations were made (Sperling and Wangenstein 1935) of the weight of consecutive 12 inch lengths of the empty small bowel in a number of dogs. There was no direct correlation between the weight of the dog and the bowel. It was observed that the bowel decreased in weight from the duodenum toward the ileum. When the terminal ileum was obstructed, however, a reversal occurred, such that the empty segments near the obstruction were the heavier.

When correction is not made for the shortening which attends acute obstruction frequently (20 to 33 per cent) the apparent increase in weight of the obstructed bowel is great (114 per cent). After allowance has been taken of this factor, however, the increase in weight though much less is still real (34 per cent).

Strength—The strength of the normal bowel wall of the dog has been examined by Cutting (1928) and again by Morton (1929). They determined the resistance offered by different segments of the gut to increases of intraluminal pressure of such a grade as to cause bursting of the wall. Cutting estimated the breaking point of the gut to be between 1 000 and 1 500 millimeters of mercury. Morton found that the bowel resisted pressures of 500 millimeters of mercury usually before the gut wall burst.

Similar determinations (twenty four in number) were made on normal bowels of animals recently killed and upon the gut where obstruction had previously been established (in twenty instances) (Sperling and Wangenstein 1935).

The bursting strength of the normal ileum of the dog was found to lie between 300 and 1 000 millimeters of mercury. The bursting pressures for jejunal segments fell within the same limits, as one would expect, however, because of the larger lumen of the more oral segments they ruptured on the whole at lower pressures than did the narrower ileal segments. Tearing or splitting of the serosa occurred at slightly lower levels of pressure.

reaches of the distended bowel, the factor of distension operates to complicate the picture. In the dog, saline solution fails to prolong the lives of dogs with ileal obstructions beyond the 7 to 9 day period, which dogs will survive ileal obstruction, if untreated. And the upsets in mineral and nitrogen metabolism, related above, are frequently not in evidence.

In man, the ileocecal valve and sphincter play a singular role in influencing the character of the symptoms as well as the effects of obstruction of the colon. In colonic obstruction the contents of the upper reaches of the gastrointestinal canal are permitted free entry to the colon, but because of the check valve nature of the ileocecal juncture, regurgitation from the distended colon into the terminal reaches of the small intestine does not occur frequently. Inasmuch as gastric retention is not present, vomiting is not a prominent feature and may be absent altogether. Regurgitant vomiting of a brownish feculent material is synonymous with obstruction of the lower reaches of the small intestine. In colonic obstructions, therefore, distension with development of high intraluminal pressures is the rule. Occasionally, one of the lips of the ileocecal valve is short or deficient (the lower usually) under which circumstance regurgitation into the ileum may accompany colonic obstruction.

Reference has been made already to the effects of obstruction to the efferent jejunal loop after the establishment of a gastro jejunal anastomosis. When obstruction occurs at the gastro jejunal stoma to the afferent loop, after gastric resection in the Billroth II type of operative procedure, or even after gastro jejunostomy performed for obstruction at the pylorus, a closed short loop type of obstruction develops with ensuing severe damage to the bowel proximal to the stoma. Death from hyperthermia occurs usually within 30 to 48 hours after operation and the cause of death is ascribed frequently to pneumonia or pulmonary atelectasis. This complication of gastric resection has been probably an important item in the mortality factor of gastric resection. Avoidance of distension of the afferent loop of a gastro jejunal anastomosis by the placement of an indwelling duodenal tube into the loop, at the time of operation will serve to eliminate the serious threat of this complication. It is to be remembered in this connection that Dragstedt, Lang and Millet (1929) pointed out that blood flow is arrested in the duodenum by intraluminal pressures which fail to obstruct blood flow to the ileum or colon (see page 231).

The effects of distension are largely manifest upon the bowel wall. High grade distensions may, of course, embarrass respiration and heart action through pressure upon the diaphragm. This influence of distension, moreover, is undoubtedly inconsiderable as contrasted with the far more serious portent of long continued distension upon the wall of the bowel.

The effect of distension upon the bowel is best assayed in terms of increased intraluminal tension. In order to measure the influence of increased pressure upon the blood supply, the absorption from and the permeability of the bowel wall, it is necessary to know the grades of pressure present in bowel obstruction. The effects of obstruction upon the length, weight, and strength of the bowel will be first briefly related.

infrequently anatomical evidence of the effects of considerable distension, these appear to be most unusual in the small bowel.

With these clinical observations in mind, efforts were made to determine the pressure in the obstructed small intestine and colon of both dog and man. A number of observations have been possible upon patients who have had an organic obstruction in the pelvic colon due to malignancy, at the time that colostomy was done, with others, an opportunity was afforded to measure the intra colonic pressure in instances where colostomy was performed before subsequent excision for carcinoma of the rectum. Pressures were determined in patients with obstruction of the small bowel directly following the placement of an enterostomy catheter into the bowel. In patients with acute obstruction of the colon, similar determinations were obtained by inserting a needle into the bowel after closure of the skin. In the instances where colostomy was done preliminary to subsequent operation upon the rectum, pressures were obtained just before opening the colostomy.

Intra enteric Pressure in the Obstructed Small Bowel

In dogs the intra enteric pressure was determined by Sperling, Paine and Wangensteen (1935) in nineteen animals in which simple low ileal obstructions had been established. Sustained pressure readings ranging from 4 to 19 centimeters of water were noted. Active peristalsis of the gut was observed invariably even after seven days of obstruction. The average sustained pressure in this group was somewhat more than 9 centimeters, the resultant pressures were as follows:

In one obstruction of 24 hours' duration the sustained pressure was 8 centimeters of water. In four obstructions of 48 hours' standing variations in sustained intraluminal pressure from 4 to 12 centimeters were found, in two of 72 hours' duration, pressures of 10 and 12 centimeters were observed, in ten animals in which the duration of obstruction was 96 hours the sustained intra enteric pressures varied between 8 and 14 centimeters of water and in two obstructions of 168 hours' standing pressures of 12 and 19 centimeters were found.

On six additional dogs seventeen measurements of intra enteric pressure were made at varying intervals after the establishment of obstruction in the following manner. A loop of gut of three to four inches in length was brought up on the abdominal wall and the adjacent skin was mobilized to cover it. When this "satchel like handle" was well healed complete obstruction was accomplished by inverting the ends of the severed terminal ileum. In a few instances, two such subcutaneous loops were made in the same dog. The usual sustained intra enteric pressure found varied between 6 and 8 centimeters of water. The highest reading obtained was 17 centimeters.

After placing an enterostomy tube in the gut in four cases of clinical obstruction of the small bowel of mechanical origin, of 48 to 96 hours duration pressures were made as described above. The sustained pressures varied between 4 and 14 centimeters of water, with peristaltic activity, occasional pressures of 20 or 30 centimeters were noted.

In the obstructed series, the reverse was found to be true. The heavier segments near the site of obstruction burst more readily than did the more oral segments, further removed from the site of obstruction. The breaking strength was found to lie between 180 and 760 millimeters of mercury.

Breaking Strength of Small and Large Intestine in Man—The breaking strength of segments of the human bowel, removed at operation, has been determined by Hay (1940). In a series of 10 patients from whom segments of intestine were removed during the removal of tumors, the bursting strength was noted to vary between 80 and 260 mm Hg of mercury. The usual range of values for the small intestine varied between 140 and 260 mm Hg. Only two colons, in this group, were available for determination of the breaking strength. In both instances, the cecum ruptured at 80 mm Hg pressure, rupture of the ileum in one of these occurred at 260 mm and, in the other, at 230 mm Hg pressure.

It would appear that the breaking strength is really a resolution of the diameter of the lumen and the thickness of the bowel wall. It was somewhat of a surprise to note at what relatively low pressures the cecum burst. However, when one recollects how distensible the cecum is, rupture of the cecum or other segments of the colon, at relatively low pressures is understandable.

The striking difference in the breaking strength of the bowel of dog and man, under the influence of increased intraluminal pressure is to be borne in mind. In neither of the two patients cited above, in which segments of colon were available for examination, was obstruction present. That obstruction lowers the breaking strength of the bowel wall, notably, has been pointed out, already, with reference to the dog.

The Intra-enteric Pressure in Bowel Obstruction

Owings, McIntosh, Stone, and Weinberg (1928) have determined experimentally on normal dogs the sustained intraluminal pressure to be 2 to 4 centimeters of water pressure. In simple ileal obstruction, a sustained pressure of 8 centimeters of water was found, and during activity of the bowel, pressures of 30 to 60 centimeters of water were obtained. In closed intestinal loops, Owings and his associates observed intraluminal pressures as high as 70 centimeters of water. In jejunal closed loops of dogs, Burget and his associates (1930) observed pressures varying from 30 to 60 centimeters of water. Morton and Sullivan (1930) compared closed jejunal loops with similar ones in the ileum. The intra-enteric pressure of the jejunal loops (52 centimeters of water) was seven times that developed in the ileal (8 centimeters). This difference in the accumulation of intra-enteric pressures, they concluded rightfully, was due to the greater secretion in the jejunal loops. A greater tendency toward perforation was observed also in the closed jejunal loops.

Observation of the effects of distension upon the bowels of patients with obstruction suggests a behavior different in the small bowel from that of the colon. Whereas the colon (and usually the cecum) exhibits not

and sphincter in obstruction of the colon Saeltzer and Rhodes (1935) have described instances too of diastatic perforation of the cecum, occasioned by obstruction of the colon Though the possibility of this occurrence was described by Heschl long ago, it is only within the past decade that surgeons have become alive to its importance

Whereas the roentgenologist can effect entry ordinarily of the small intestine with barium administered as an enema, he employs usually an elevation of gravity pressure of more than three feet (90 centimeters)



FIG 9—Check valve mechanism of lips of ileocecal valve and sphincter Increasing tension in the cecum approximates the lips of the ileocecal valve indicating how a closed loop obstruction develops with colonic occlusion Deficiency of one of the lips would permit regurgitation into the ileum

and in addition employs manipulation of the abdominal wall It will be recalled that the greatest pressure measured in the five cases of clinical obstruction of the colon was 52 centimeters of water and that such pressures exceed 25 centimeters of water rarely Inasmuch as barium is considerably heavier than water it is immediately apparent that the roentgenologist employs pressures far in excess of those which develop spontaneously in the colon Furthermore, undoubtedly there is also a vast difference between gradual accumulation of pressure in the colon in its effect upon the ileocolic sphincter and valve and that observed when the colon is distended rapidly with an enema

The Intra-colonic Pressure in Obstruction

Pressures were obtained at operation when colostomy was performed for relief of distension in five cases of acute colonic obstruction due to malignancy. The sustained pressures varied in these five cases between 12 and 52 centimeters of water, in four of the cases pressures above 23 centimeters of water were recorded, much higher figures than were observed in the small bowel. The duration of obstruction in these cases varied between three and eight days. Determination of the intra colonic pressure, in obstructed colons, is made regularly now, in the manner indicated in Fig 30, on completion of transverse colostomy aimed at relief of the obstruction. Intraluminal pressures of 10 to 25 centimeters of water pressure are the usual findings.

In twelve other cases in which colostomy was done preliminary to excision or other operation upon the rectum, pressures were obtained by inserting a needle into the exteriorized bowel. Pressures varying between 10 and 26 centimeters of water were obtained. In all of the cases suction had been applied constantly to an intubing duodenal tube following the colostomy. Consequently opportunity was not afforded for building up as great pressures as would have occurred otherwise. Nevertheless the occurrence of intraluminal pressures of this grade in the colon, despite the exertion of suction in the upper reaches of the intestinal canal, indicates the futility of duodenal intubation in influencing the established distension in cases presenting acute obstruction of the colon.

The Influence of the Ileocecal Sphincter and Valve

A number of factors indicate that the ileocecal sphincter and valve may convert a simple obstruction of the colon into a closed loop obstruction. In instances of acute obstruction of the colon operated upon despite enormous distension of the colon the terminal ileum has frequently been observed not to be distended. Not infrequently in neglected cases of acute obstruction of the colon, the bowel may perforate despite absence of vomiting. These perforations are usually in the cecum, the portion of the bowel having the greatest diameter and consequently most dilatable. Even though the intraluminal pressure is the same in the cecum as it is in the narrower descending colon the stress on the bowel, borne by the walls of the cecum, is as much greater than that of the descending colon as is its greater volume.

Hechl (1880) was the first to call attention to the importance of the ileocecal valve and sphincter in causing diastatic perforation of the cecum in the presence of colonic obstruction. Later Anschuetz (1902) reiterated the importance of its occurrence. Shimodaira of Kocher's clinic (1911) collected forty eight cases of perforation of the bowel attending obstruction of the colon. The majority were in the cecum. This occurrence was first noted in this clinic in 1931 and in 1934 the writer was convinced that the symptoms of large and small bowel obstruction could be differentiated frequently on the basis of the behavior of the ileocecal valve.

sponsible for the migration. In this connection, it may be said that reversals of the intestine in the dog are not tolerated well and such animals die of obstruction (Mall 1896, Prutz and Ellinger 1902, 1904). Enderlen and Hess (1901) noted that reversal of the intestine could be tolerated. The writer observed too, a number of years ago, that if shorter lengths were reversed and the operation carried out in stages, surprisingly long segments of the small intestine in the dog could be reversed. The writer has also made an antiperistaltic anastomosis between a loop of jejunum and the stomach in man, transplanting the jejunal loop beneath the skin for feeding, without observing any notable difference in the behavior of such a loop, and one in which the normal intestinal gradient is toward the stomach. These considerations, as well as ability of the patient to empty, at least partially through the agency of vomiting, a distended loop of bowel suggests that, reversed contractile activity may occur in the intestine.

Effects of Increased Intra enteric Pressure Upon the Bloodflow to the Bowel

It is apparent that increases in intraluminal pressure in instances of bowel obstruction may affect unfavorably the blood supply of the gut. van Zwalenburg (1907) studied the effect of distension upon bloodflow through the bowel wall of the dog by means of an electric bulb within the lumen. He observed capillary stasis at 30 millimeters of mercury pressure, venous stasis at 60 millimeters, partial arterial arrest at 90 millimeters, and finally complete arrest of the circulation at 130 millimeters. Gatch, Trusler, and Ayres (1927) cannulated the mesenteric veins returning from closed loops and measured the minute volume flow under experimentally increased intra enteric pressure. For each increment of increased intraluminal pressure a corresponding decrease in bloodflow occurred. Dragstedt, Lang, and Millet (1929) made similar determinations at different levels of the intestinal canal and found that the circulation of the duodenum was more profoundly affected than any other portion of the bowel by increased intra enteric pressure.

The pressures employed by these investigators, however, were far in excess of the sustained pressures observed in experimental or clinical obstructions of the small intestine. Gatch and his associates observed, when no resistance was offered to the return flow of blood from the mesenteric vein of an isolated intestinal loop, that an average return of 18 cubic centimeters per minute was noted in six dogs. When the intraluminal tension was raised to 25 millimeters of mercury pressure, an average return of 17 cubic centimeters per minute was observed. At 50 millimeters pressure, the return flow was 13 centimeters per minute, and at 75 millimeters, it was still 10.1 centimeters. Even at 200 millimeters pressure, an average return flow of 3 centimeters per minute was observed. Inasmuch as this pressure exceeds considerably the arterial blood pressure of the dog, it is apparent, as the authors conclude rightfully, that, there is a residual circulation through the minute vessels of the mesentery, which cannot be wholly arrested by increase of intra enteric pressure.

The Anatomy of the Ileocecal Sphincter and Valve

Textbooks of anatomy describe the ileocecal sphincter as a collection of circular and oblique muscle fibres surrounding the insertion of the two folds of mucous membrane of the terminal ileum into the colon. These folds project into the lumen of the colon and are known as the upper and lower lips of the ileocecal valve. Its innervation and function have been studied by Hinrichsen and Ivy (1931), who concluded that it exhibited properties of a physiologic sphincter, that its tone was maintained by sphincteric stimulation, and that the vagus carried both motor and inhibitory fibres to the sphincter.

The manner of insertion of the terminal ileum into the colon permits the lips of mucous membrane supported by the smooth muscle beneath to act as a check valve, such that fluid and gas may be emptied into the colon from the ileum, but having entered, their regurgitation back into the small intestine is prevented by the closure of the folds of mucous membrane. The lips of the ileocecal valve, however, when incompletely developed, would not exhibit this check valve action. On studying autopsy specimens of ileocecal valves from man, Buirge (1939) found that one valve, usually the inferior was deficient in an appreciable per cent of instances. Sperling (1936) has studied the nature of the behavior of the ileocecal valve and sphincter in both man and dog in some detail.

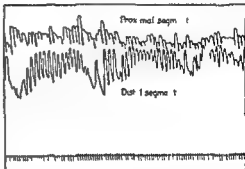


FIG 10—Activity of bowel proximal and distal to obstruction. Copy of a kymographic tracing made in a dog with complete ileal obstruction of six days duration with a balloon in both the proximal and distal loops. The activity of both obstructed and unobstructed bowel is great. The unobstructed bowel is physiologically as well as anatomically normal. Expulsion of gas and feces with an administered enema does not therefore militate against the presence of obstruction (Arch Int Med 46 669 1930).

Contractile Activity of Obstructed Bowel

Brandberg (1939) has given the matter of the motor activity of the obstructed bowel special consideration. Employing an abdominal window, he observed first increased contractions, and with accretion of intestinal distension and impairment of the mesenteric circulation attending it decreased intestinal activity. Carlson and Wangenstein (1930) noted good contractile activity of the bowel proximal and distal to the obstruction several days after the establishment of obstruction in dogs.

The question of antiperistaltic activity in the obstructed bowel has not been settled wholly. The recovery of lycopodium powder from the stomach after administration in an enema, Brandberg states is occasioned by action of the muscularis mucosae, which sets up a marginal current re-

TABLE VII—EFFECT OF SUSTAINED INTRA ENTERIC PRESSURE UPON THE APPEARANCE PERMEABILITY, AND VIABILITY OF THE ILEUM

Dog	Pressure applied cm	Reoperated after hrs	Anatomy	Permeability	Viability
1	10 fluid	25	Petechial hemorrhage on anti mesenteric border	Negative	Viable
2	10 air	27	Petechial hemorrhage on anti mesenteric border, some bloody fluid in lumen of gut	Negative	Viable
3	20 fluid	10	Congested Congestion marked Hemorrhagic peritoneal fluid definite areas of necrosis on anti mesenteric border	Negative	Viable
		22		Negative	Impaired
		28		Positive	Non viable
4	20 air	22	Congested Dog dead necrotic areas	Negative	Viable
		32		Positive	Non-viable
5	40 fluid	2	Negative	Negative	Viable
6	40 air	4	Hemorrhages on anti mesenteric border	Negative	Viable
7	40 fluid	11	Congested bloody fluid in peritoneal cavity Dog dead areas of necrosis	Negative	Viable
		17		Positive	Non viable
8	40 fluid	28	Areas of necrosis on anti mesenteric border	Positive	Non viable
9	40 air	20	Split aorta gangrenous patch on anti mesenteric border	Positive	Non viable
10	40 air	20	Two areas of necrosis on anti mesenteric border	Positive	Non viable
11	40 fluid	20	Hemorrhagic areas and beginning areas of necrosis Necrosis spreading Two small distention ulcers on mucosal surface	Negative	Viable
		24		Negative	Non viable
		30		Positive	Non viable

for evidences of abnormal permeability in the wall of the distended bowel. At intervals the abdomen of the dog was reopened and the surfaces of the distended loop were sponged with a 1 per cent solution of ferric chloride. Penetration of the potassium ferrocyanide through the gut wall was heralded by the appearance of a definite Prussian blue color. At the time of the reopening of the abdomen, the viability of the distended loops was tested by faradic stimulation. Failure of the bowel wall to contract when stimulated with two dry cells, with the coils 8 centimeters apart, was

Effect of Constantly Sustained Pressure

In order to better evaluate the significance of the increased pressures which have been noted to exist in experimental as well as clinical obstructions, the intestine was subjected to sustained pressures of the grades observed and the bowel wall was carefully studied to note the effects of distension

Sperling and Wangenstein (1935) subjected closed ileal loops in the

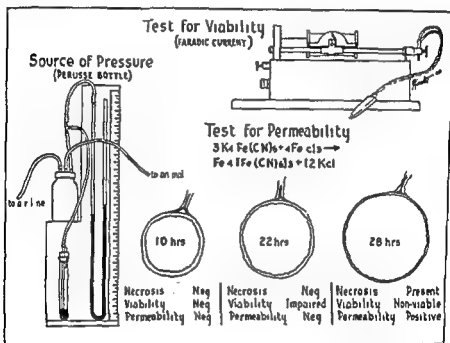


FIG 11—Schematic summary of effects of sustained intraluminal pressure in closed loops (See Table 12) Necrosis indicates histologic evidence of tissue injury response to the faradic current was used to indicate whether the bowel was viable (see text) The appearance of a Prussian blue color after daubing Ferric chloride on the exterior of the bowel indicated that the potassium ferro-cyanide had come through and that the bowel had become abnormally permeable At the left is shown the Perusse pressure bottle

dog to sustained increases of intraluminal pressure, maintained for hours at a predetermined level This objective was accomplished by employing the Perusse pressure bottle (Fig 11) The levels of pressure maintained were 10, 20 and 40 centimeters of water—pressures within the range of those observed clinically and following experimental obstruction in the dog The dogs, in these closed loop experiments, were maintained quiet under pentobarbital sodium (nembutal) anesthesia, reinforced with morphine for the duration of the experiment The anatomic effects of such distension are indicated in Table 12 Placement of 30 cubic centimeters of a 5 per cent solution of potassium ferrocyanide into the lumen of the closed loop prior to distending it, afforded at the same time, opportunity to test

TABLE XII—EFFECT OF SURTENSION
APPEARANCE ILEUMFERRIC PRESSURE UPON THE
VIABILITY OF THE ILEUM

Dog	Pressure applied cm	Reopened after hrs	Findings	Permeability	Viability
1	10 fluid	29	1st	age on anti 1st	Negative Viable
2	10 air	27	1	ri age on anti 1st order some lumen of gut	Negative Viable
3	20 fluid	10 22 24	marked peritoneal fluid areas of necrosis on enteric border	Negative Negative Positive	Viable Impaired Non viable
4	20 air	3	1 1 necrotic areas	Negative Positive	Viable Non viable
5	40 fluid		active	Negative	Viable
6	40 air	4	11 hemorrhages on anti mesen- teric border	Negative	Viable
7	40 fluid	1	1 congested bloody fluid in peri- toneal cavity	Negative	Viable
		1	1 Dog dead areas of necrosis	Positive	Non viable
8	40 fluid	28	Areas of necrosis on anti enteric border	Positive	Non viable
9	40 air	20	Split serosa gangrenous patch on anti mesenteric border	Positive	Non viable
10	40 air	20	Two areas of necrosis on anti mesenteric border	Positive	Non viable
11	40 fluid	20 24 30	Hemorrhagic areas and begin- ning areas of necrosis Necrosis spreading Two small distension ulcers on mucosal surface	Negative Negative Positive	Viable Non viable Non viable

for evidences of abnormal permeability in the wall of the distended bowel. At intervals, the abdomen of the dog was reopened and the surfaces of the distended loop were sponged with a 1 per cent solution of ferric chloride. Penetration of the potassium ferrocyanide through the gut wall was heralded by the appearance of a definite Prussian blue color. At the time of the reopening of the abdomen, the viability of the distended loops was tested by faradic stimulation. Failure of the bowel wall to contract, when stimulated with two dry cells, with the coils 8 centimeters apart, was

Effect of Constantly Sustained Pressure

In order to better evaluate the significance of the increased pressures which have been noted to exist in experimental as well as clinical obstructions, the intestine was subjected to sustained pressures of the grades observed and the bowel wall was carefully studied to note the effects of distension.

Sperling and Wangenstein (1935) subjected closed ileal loops in the

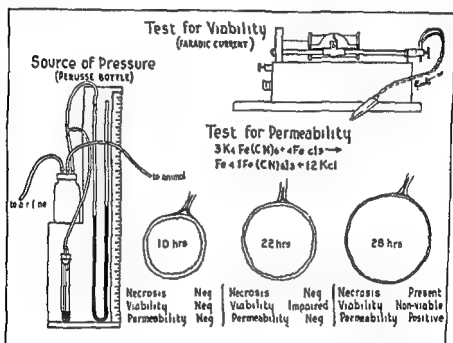


FIG 11—Schematic summary of effects of sustained intraluminal pressure in closed loops (See Table 12) Necrosis indicates histologic evidence of tissue injury, response to the faradic current was used to indicate whether the bowel was viable (see text) The appearance of a Prussian blue color after daubing Ferric chloride on the exterior of the bowel indicated that the potassium ferro-cyanide had come through and that the bowel had become abnormally permeable At the left is shown the Perusse pressure bottle

dog to sustained increases of intraluminal pressure, maintained for hours at a predetermined level This objective was accomplished by employing the Perusse pressure bottle (Fig 11) The levels of pressure maintained were 10, 20 and 40 centimeters of water—pressures within the range of those observed clinically, and, following experimental obstruction in the dog The dogs, in these closed loop experiments, were maintained quiet under pentobarbital sodium (nembutal) anesthesia, reinforced with morphine for the duration of the experiment The anatomic effects of such distension are indicated in Table 12 Placement of 30 cubic centimeters of a 5 per cent solution of potassium ferrocyanide into the lumen of the closed loop prior to distending it afforded, at the same time opportunity to test

obstructions. He found that the rubor of the bowel was explained by the dilated vessels in its wall. The vessels themselves were intact.

The only significant changes present in this study were observed in the mucosa. Swelling of the villi as well as shortening and clubbing described above in the artificially distended segments were constant findings. Loss of the epithelial tips of the villi in specimens both from above and below the site of obstruction were occasionally noted. Areas of leucocytic invasion or evidence of necrosis of the bowel wall were absent uniformly.

Comment—It is to be observed that whereas sustained intra enteric pressures of the grades demonstrated to exist in at least some cases of bowel obstruction caused anatomical changes in the bowel wall (Table VII, pressures of 20 and 40 centimeters) these were not observed in any of the thirty five cases in which experimental simple obstructions were established. This occurrence bespeaks the importance of the great ability which all hollow muscular viscera such as the bladder, stomach, and intestine exhibit to accommodate themselves to altered capacities without significant changes in tension. Whereas sustained pressures in clinical cases of small bowel obstruction were observed to vary between 4 and 14 centimeters of water and in experimental obstruction of the small bowel of the dog between 4 and 19 centimeters, these were after all in each instance single observations made over a period of some few minutes. The artificially produced increases of intra enteric pressure were maintained over hours. Undoubtedly the bowel wall, within certain limits, is able to maintain an adequate blood supply through the process of stretching of its circular muscle. The dilatation of the small bowel observed experimentally as well as clinically occurs so gradually that considerable distension may be present without marked increase in tension. Yet, it is to be admitted freely, that the lower segments of a long stretch of obstructed bowel, in which the effects of long continued increases of sustained intraluminal pressure become most manifest are exposed to the same hazards that befall closed segments submitted to a constantly maintained intraluminal pressure.

Influence of Length of the Segment

The length of the segment concerned is obviously of great importance. The small bowel of the dog is considerably shorter than that of man and in consequence its lower reaches when obstructed may be evacuated with greater ease by retrograde peristalsis and vomiting than the lower ileum of the obstructed human gut. Nevertheless, this feature of regurgitation into more proximal segments is undoubtedly the factor which is of paramount importance in preserving an adequate blood supply to the obstructed small intestine. Its significance for the nutrition of the bowel wall may be appreciated better by referring to the absence of this occurrence in clinical cases of acute obstruction of the colon. It should be stated here that though the ileocecal sphincter of the dog resists distension as has been related previously when dogs survive colonic obstruction for some time the terminal small intestine is found dilated usually. On the contrary in acute mechanical obstruction of the colon in man, the

taken as evidence of impaired viability

A summary of the anatomic findings, together with the status relating to permeability and viability is to be found in the accompanying table (Table 12). It is to be observed that the time over which the pressure acts though not of the same significance for the bowel as the degree of pressure acting, is, nevertheless, very important. It is to be noted that the continuous application of 10 centimeters sustained intra enteric pressure for 27 or 28 hours (dogs 1 and 2) caused petechial hemorrhages in the gut, even though the bowel was viable and no abnormal permeability for potassium ferrocyanide was demonstrated. The employment of 20 centimeters water pressure for 28 or 32 hours (dogs 3 and 4) caused areas of necrosis and the bowel was no longer viable as tested by response to faradic stimulation, it was also abnormally permeable. When pressures of 40 centimeters were employed, the bowel exhibited invariably necrotic areas after 17 to 20 hours and was abnormally permeable and non viable. Sperling (1938) has elaborated upon these observations.

Histology of the Bowel Wall

Histologic studies made upon the bowel wall, in the viable segments, showed thinning of the wall and prominent blood vessels exhibiting collections of red cells. There was no interstitial hemorrhage. Edema, shortening and clubbing of the villi were fairly constant findings. In the nonviable segments interstitial hemorrhage and erosion of the mucosa were invariable findings.

Histologic studies were made also upon the bowel in a number of instances of experimental simple intestinal obstruction. One or two specimens were taken from the bowel distal to the obstruction and one to four specimens were removed from the obstructed proximal gut at various levels between the pylorus and the point of obstruction. The entire proximal bowel was opened up and specimens were selected from areas that appeared to deviate from the normal in gross appearance. These tissues as well as pieces selected for histologic study of the segments which had been subjected to sustained increased pressure listed above, were fixed in formalin or Zenker's solution, imbedded in paraffin, and microscopic slides were prepared employing the hematoxylin and eosin stain.

Tissues from nine dogs with duodenal obstruction varying in duration from three to six days were available for study, seventeen ileal obstructions of two to fourteen days' duration, and nine colonic obstructions of two to nineteen days' standing.

Grossly all the distended obstructed segments exhibited redness of the bowel wall. No areas of necrosis of the wall or mucosal ulceration were seen in any of these thirty five obstructions. No evidence of interstitial hemorrhage was observed in any of the sections studied microscopically. The rubor of the bowel wall was adequately accounted for in the constant finding of collections of red cells in dilated blood vessels. These observations are in accord with the conclusions of Morton (1929), who injected the blood vessels to the bowel wall with India ink after experimental

however support the opinion expressed by Burget and his associates that a low level of blood chloride does not accompany devitalization of the bowel wall *per se*

It has been pointed out already that the greatest stress is borne by that portion of the dilated gut which has the largest diameter. With knowledge of the sustained intra enteric pressure and the measurement of the diameter of the distended segment, the tension is calculated readily. The tension T , on every centimeter of surface of the segment will be equal

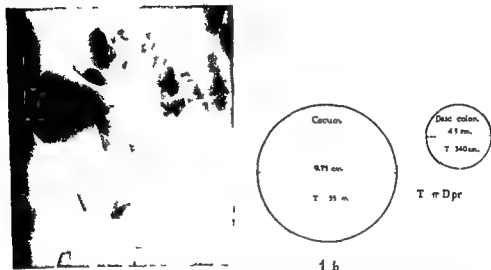


FIG 12—The role of the ileocecal valve and sphincter in acute obstruction of the colon (a) The distension of the colon in a patient with an obstructing annular carcinoma in the pelvic colon. The ileocecal sphincter precludes regurgitation into the ileum and creates a closed loop obstruction (b) The tension on the walls of the obstructed bowel in the cecum and descending colon is indicated in the accompanying sketches

to the diameter, D in centimeters multiplied by π , times the intra enteric pressure, P , in centimeters of water. How the diameter affects the tension may be shown readily by the following. A patient with an acute obstruction of the pelvic colon presented himself with the distension shown in Figure 12. The greatest diameter of the distended bowel was 13 centimeters in the cecum, the diameter of the descending colon was 8 centimeters. At operation a carcinoma was found in the pelvic colon. The entire anterior wall of the cecum was gangrenous from which complication the patient died despite successful decompression. Unfortunately the intra enteric pressure was not measured, but it has been determined in similar cases which will be referred to in a subsequent section of this paper. Let us assume that the intra enteric pressure was 24 centimeters, which is well within the limits of pressures actually measured in similar cases. The difference in stress borne by the cecum and descending colon is indicated in the accompanying calculation. Inasmuch, however, as the film is made with the patient lying supine, the intestinal coils are a

distension is limited usually almost invariably to the colon itself. The ileocecal valve and sphincter in man behave like a check-valve and preclude frequently the regurgitation of colonic contents back into the ileum. The capacity for dilatation is possessed by the colon in the same degree as the small intestine, but there being no participation in the distension by the small intestine, such an obstruction becomes virtually a short, closed loop obstruction. Whereas experimentally produced closed loops of the colon (both ends closed) may be well tolerated, when the contents of the ileum are poured into the obstructed colon and no avenue is present for their escape, the occurrence of anatomical changes in the bowel wall and perforation may be understood readily. Whereas several instances of perforation of the obstructed colon have come under the observation of the writer, no instance of perforation of the small intestine among a much larger number of clinical cases of simple obstruction has been seen. However, as explained above, the lower reaches of a long stretch of distended bowel are subjected to the same hazard, as attends closed loops. Lufkin (1938) has observed actual perforation in simple obstruction of the small bowel in man. The end effects of distension upon segments of bowel, subjected to an unrelenting stretch, are undoubtedly similar to primary strangulations in which the blood flow is compromised. The shock like effects of terminal simple obstruction, described by Moon and Morgan (1930), are understandable in the light of the demonstrated increased permeability of distended intestinal loops.

The verity of these observations concerning the distension factor is further borne out by a large number of investigators who have worked with closed intestinal loops. This significant method of studying the effects of bowel obstruction was introduced by Stone, Bernheim and Whipple in 1913.

The Hydraulic Stress Factor

The significance of the hydraulic factor in determining the course of events in animals having closed loops was pointed out by Sweet and associates (1916) who said, "It is only because of such distension and consequent rupture that our animals with closed loops die." The greater danger inherent in the upper intestinal loop has been noted by a number of investigators, as has also that, longer loops are better tolerated by the animals than the short ones. Burget and his associates (1930) were able to have some dogs survive short closed jejunal loops for months by periodically aspirating their content. When the closed loop was not aspirated, the dog manifested obvious signs of illness and would not eat. These symptoms were relieved uniformly by aspiration. Histological studies of aspirated loops showed no alteration, whereas necrosis and perforation occurred in those not aspirated. Herrin and Meek (1933) have produced similar symptoms in dogs by artificially distending intestinal loops. Unlike the findings of Burget and his associates, however, Herrin and Meek believed that significant losses of chloride were produced by distension which gave rise to the typical blood chemical alterations attending obstruction of the upper reaches of the intestine. The findings of a number of investigators

nerivation of the loop was carried out, survived establishment of such closed intestinal loops for 3 weeks to 4 months

The experiments suggest a definite role of the nervous factor in the production of the symptoms and effects of a closed loop. Yet, it is essential to know what the effect of denervation, accomplished in this manner, is on the secretion of the loop. It is significant that Fine and his associates (1939) were unable to detect any difference, in behavior, of denervated closed loops over controls, when denervation was carried out by removal of the celiac ganglia.

C THE SYSTEMIC EFFECTS OF INTESTINAL DISTENSION

Intestinal distension, inadequate in degree to embarrass respiration, may, nevertheless exercise a measurable objective effect upon the circulation. In patients with obstruction of the small intestine or the colon exhibiting intraluminal pressures (determined at operation) from 14 to 20 cms. of water pressure Bellis and the writer (1939) observed definite elevation of the venous pressure in the ankle veins of the lower extremity

TABLE VIII—VENOUS PRESSURE (ANKLE VEIN) AND CIRCULATION TIME (ANKLE VEIN TO CAROTID SINUS BY SODIUM CYANID METHOD) IN PATIENTS WITH CLINICAL INTESTINAL DISTENSION

Case	Venous pressure ankle (cm water)	Circulation time (seconds)	
		Cubital to carotid	Ankle vein to carotid
1 Carcinoma of pelvic colon with acute obstruction, pressure at operation 20 cm water 1800 cc gas aspirated	12	20	52
2 Carcinoma of pelvic colon pressure at operation 15 cm water 1500 cc gas aspirated	15.5	19	No response in horizontal 22 in 30 Trendelenburg
3 Carcinoma of stomach with distension owing to metastases	17.5	18	No response in horizontal 15 in 30 Trendelenburg
4 Mass in terminal ileum treated conservatively by suction 5 days later ileostomy intraluminal pressure 14 cm water 600 cc gas and fluid aspirated at operation	3	22	35
5 Abdominal injury with marked intestinal distention treated conservatively by suction applied to indwelling duodenal tube	29	12	49

Downward inclination

(12 to 29 cms. of saline pressure) before surgical relief of the distension was undertaken. There was observed also a consistent definite prolongation of the circulation time in the lower extremity (35 to 52 seconds, as

considerable distance from the film and appear in consequence much larger than they actually are. The degree of enlargement of intestinal diameter as determined by a comparison of the measurements made upon the obstructed bowel at operation and that observed on the roentgen film is in the neighborhood of 25 per cent, because of the divergence of the x-rays. Allowing for this error, the stress T upon the walls of the two segments will be as follows:

For the cecum

$$T = 3.14 \times 13 \times 24 \times 0.75,$$

$$T = 735 \text{ centimeters of water pressure per centimeter of surface}$$

For the descending colon

$$T = 3.14 \times 6 \times 24 \times 0.75,$$

$$T = 340 \text{ centimeters}$$

The frequency with which perforation is observed in the cecum in late or neglected cases of obstruction of the pelvic colon is apparent immediately in the difference of stress or tension exerted on the walls in segments of varying diameter as indicated by this calculation.

Neurogenic Factor in Closed Loops

Lawson and Chumley (1940) have studied recently the blood flow to distended intestinal segments in the dog. Employing a closed intestinal loop, and pressures not less than 30 millimeters of mercury nor more than 60, in acute experiments of short duration (not more than five minutes), they failed to observe any evidence of significant differences of blood flow, during the period of distension. Lawson and Chumley believe that stretching of the bowel wall, incident to distension, either reduces the resistance to the flow of blood, or, sets in operation a peripheral nervous mechanism which lowers resistance to blood flow, by compensating for the rise in extravascular (intra enteric) pressure. The ultimate compensating mechanism, they believe, is, probably, dilatation of the intestinal arterioles. When Lawson and Chumley prevented enlargement of the intestinal loop by encasing it in plaster of Paris, prior to distending it, or, when the loop was treated with cocaine or procaine, rises in intra enteric pressure were followed consistently by reduction in blood flow, which persisted throughout the period of distension.

A number of investigators, Burget and his associates (1930), Herrin and Meek (1933), Taylor and his associates (1933), Antoncic and Lawson (1941) amongst others have observed lesser symptoms and longer survivals in dogs with closed intestinal loops, attending denervation of the loops. Antoncic and Lawson, who studied this nervous factor most recently, cut the periaarterial tissue about the blood vessels in the loop concerned, and then painted the denuded area over the vessels with a 20 per cent solution of phenol. In other experiments, they infiltrated the mesenteric pedicle of the closed loop with 95 per cent alcohol. Whereas, the control dogs died in 36 hours to 7 days, 11 of 23 dogs in which de-

about in that the blood has yet to flow through the liver capillaries (Table XIV)

It is clear, therefore, that distension causes stasis of blood in the lower extremities, and in the gut itself Aird (1937) and Gendel and Fine (1939) have described reduction in plasma volume in ileal obstruction in dogs. Both groups of writers felt that the loss in plasma volume was inadequate in amount to cause death. When, however, Gendel and Fine subjected the obstructed loops of intestine to sustained intraluminal pressures of 20 to 40 cms of water sufficient losses of plasma to cause death were the rule. In a recent communication (1940) Fine and Gendel state that while the loss of plasma is not the only significant phenomenon in the lethal

TABLE XIV—RELATION OF INTRALUMINAL PRESSURE IN BOWEL OF DOGS TO MESENTERIC VENOUS PRESSURE ATTENDING INFLATION OF GUT WITH AIR

Intraluminal pressure (cm water)	Mesenteric venous pressure (cm water)
0	13
10	12
20	12
30	12
40	10
50	6
60	5.5
70	5
80	5
90	0
100	6

process of intestinal obstruction they feel it is the only one brought forward thus far which may be regarded as basic in importance."

This writer feels, on the contrary, that significant plasma losses in bowel obstruction apart from the segregation of blood in the lower extremities occasioned by intestinal distension is a measure of impaired viability of the bowel wall. Since the observations of Bayliss and Starling (1894) it is known that the capillaries of the intestinal mucosa and the liver are more permeable to protein than are other capillary blood vessels. Yet as Landis (1934) has indicated capillaries unless injured retain 95 per cent of the plasma protein. Whereas peritoneal fluid can be collected regularly containing protein in abnormal amounts (3 to 6 per cent) after long intestinal loops have been subjected to sustained increases of intraluminal pressure of 10 to 20 cms of water pressure for some time, it is often difficult to collect fluid from the peritoneal cavity of the dog with ileal obstruction until shortly before death. Fluid is no doubt, filtered through the capillaries into the peritoneal cavity, but only when the intestinal capillaries become injured through prolonged distension and anoxia with consequent abnormal leakage of protein through the capillaries does the circulatory mechanism break down, paralleling the situation observed in peritonitis.

well as occasional absence of response—ankle vein to carotid sinus by the sodium cyanid method) over the circulation time in the upper extremity (12 to 22 seconds) Employment of the steep Trendelenburg posture (downward inclination of head and entire body at 30 degree angle) resulted in considerable acceleration of the circulation time in these same patients exhibiting intestinal distension (Table VIII)



FIG 13—Intraintestinal air insufflation and its effects on venous pressure Relation between arterial blood pressure femoral venous pressure inferior vena cava pressure intraperitoneal pressure and portal venous pressure Intrajejunal pressure 50 cm water (Bellis and Wangenstein Proc Soc Exp Biol & Med 41 490 1939)

Attending maintenance of an intraluminal pressure in the bowel of 50 cm of water pressure, by the intrarectal insufflation of air, a gradual reduction of the arterial pressure occurs (Fig 13) The femoral vein pressure rises, the vena cava pressure remains largely uninfluenced, due probably to the protection which its strong fascial sheaths afford, the portal vein pressure falls slightly and the intraperitoneal pressure interestingly enough does not reflect directly the intra enteric pressure—the intraperitoneal pressure lagging definitely behind the intra enteric pressure

In dogs, it was observed that inflation of the bowel, to the extent that considerable intestinal distension resulted, reduced the venous pressure in the mesenteric veins That is, the rate of outflow of blood from the gut was reduced The initial mesenteric venous pressure was reduced from 12 cms of saline solution to 0 and 5 cms It is to be remembered that this relatively high normal venous pressure in the portal tributaries comes

that such may occur. And justifiably so, for does not the intact intestinal cylinder afford the organism adequate protection daily against fatal infection and other potential serious menaces which constantly threaten? The most important element in the bowel wall responsible for providing this protection is undoubtedly the mucosa. There is little wonder that no one can put aside wholly the thought that abnormal absorption may occur, particularly when changes, even though slight, such as edema or clubbing of the villi may be seen in histologic sections of the obstructed bowel whose wall is otherwise histologically normal.

The Avenues of Absorption

The normal mode of absorption from the bowel is through its mesentery and may occur by the lymphatics or through the mesenteric radicles of the portal vein. In addition it is believed that under conditions of obstruction, transperitoneal absorption through the bowel wall itself may obtain also. It is therefore of the utmost significance to determine how obstruction and increased intra intestinal pressure influence absorption from the bowel.

Absorption of Substances to which the Normal Bowel Is Permeable

It has been demonstrated adequately that the obstructed bowel permits the absorption of substances from its lumen to which the normal bowel wall is permeable. Braun and Borrutau (1908) found that strychnine is absorbed from the obstructed intestine of the dog but at a slower rate than from the normal intestine. Clairmont and Ranzi (1904) found in the first ten hours following the establishment of obstruction in the dog that absorption of calcium iodide was increased; after ten hours its absorption was reduced in amount and after fifteen hours absorption sank quickly to a low level. Enderlen and Hotz (1911) observed that the absorption of various concentrations of saline solution and dextrose was reduced from the intestine of obstructed dogs from the start.

Absorption of Water from the Normal and Obstructed Bowel

Sperling (1938) studied the absorption of water from normal and obstructed bowel in dogs. In four normal dogs, eighteen inches of the lower ileum was isolated by stripping this length of its content by a "milking" process. A rubber covered clamp was applied at each end. Tap water the temperature of which was 40° centigrade, was then injected into the lumen of this isolated loop to completely fill the loop without stretching the bowel. A similar procedure was done in two dogs in which ileal obstruction had been established four days previously. The eighteen inches of ileum to be selected in the obstructed dogs was demarcated at the time of obstruction to eliminate error due to alteration of the bowel length (shortening) which occurs with obstruction.

The obstructed bowel Sperling observed absorbed only 8 to 10 per cent of the amount of water introduced, whereas in the normal 55 to 94 per cent was absorbed. It would appear therefore, that water absorption is considerably retarded from an obstructed bowel.

Neither is it likely that this phenomenon of plasma loss is peculiar to the small intestine as Fine and his associates have suggested. Bellis and the writer (1939) observed increases in venous pressure in the lower extremities and delay in circulation time in colonic as well as small bowel obstructions. The total length of the colon, it is to be borne in mind, constitutes only about 20 per cent of the entire length of the bowel. And the frequent limitation of distension to the colon by the lips and sphincter of the ileocecal valve in colonic obstructions has been described above. Undoubtedly, therefore, the greater surface area involved in obstructions of the small intestine suggests that this phenomenon may be observed more often in small bowel obstructions.

The abnormal leakage of plasma protein through the intestinal capillaries accompanying the distension of obstruction indicates, as does transperitoneal migration of colloidal dyes, bacteria and other noxious agents such as strychnine and botulinum toxin placed in the lumen of the gut that the viability of the intestinal wall has become impaired by venous stasis and anoxia.

D ABSORPTION IN OBSTRUCTION

The toxin absorption idea has held sway for a long time as the important factor in the lethal issue of bowel obstruction. It is probably the oldest of all the theories seeking to explain the cause of death in intestinal obstruction. More than a century ago, Amussat (1839) gave renewed emphasis to its importance. Up until recently it has continued to lead the field, amongst plausible causes, as the most significant lethal factor in intestinal obstruction. From filtrates of the intestinal content obtained from obstructed animals toxins have been isolated: heteroproteose (Whipple and associates), histamine (Gerard), nucleoprotein (Ingvalden and associates) and choline and neurine (Nesbitt). A number of observers noted that normal intestinal content is equally as toxic as that from obstructed intestinal segments (Roger and Garnier (1905), Wangenstein and Chunn (1928), Gatch, Trusler and Lyons (1934) and Van Beuren (1935)).

That bacteria multiply in obstructed intestinal loops has been demonstrated adequately (MacNeal and Chase 1913, Gorke 1922 and Meloney, Jobling and Berg 1927). The Dragstedts (1922) observed that preliminary washing and chemical sterilization, in so far as a practical elimination largely the hazard of closed intestinal loops. Davis and Stone (1913) found that mucosal preparations from obstructed intestine lost their toxicity after elimination of the bacteria from the filtrate. Scott (1938) observed that, following autoclaving, excised intestinal loops could be implanted into the peritoneal cavities of other dogs, with impunity.

In addition to consideration of the presence of an abnormal toxin in intestinal obstruction, foreign to the unobstructed bowel, the item of absorption of substances, normally present within the lumen of the bowel, but to which the normal bowel wall is impermeable, is given wide credence as an item of great importance, in bringing about the lethal issue in intestinal obstruction. Even in the minds of those who have tried and failed to demonstrate proof of abnormal absorption, there still lurks the fear

that such may occur. And justifiably so, for does not the intact intestinal cylinder afford the organism adequate protection daily against fatal infection and other potential serious menaces which constantly threaten? The most important element in the bowel wall responsible for providing this protection is undoubtedly the mucosa. There is little wonder that no one can put aside wholly the thought that abnormal absorption may occur, particularly when changes, even though slight, such as edema or clubbing of the villi, may be seen in histologic sections of the obstructed bowel whose wall is otherwise histologically normal.

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The obstructed bowel Sperling observed absorbed only 8 to 10 per cent of the amount of water introduced, whereas in the normal 82.5 to 94 per cent was absorbed. It would appear therefore that water absorption is considerably retarded from an obstructed bowel.

Absorption of Histamine from the Obstructed Bowel

Mucosal extracts of dogs ill of obstruction, when injected intravenously into normal dogs, cause them to be profoundly ill accompanied by considerable depression of the arterial blood pressure. Though a number of investigations show that no toxin is present in the obstructed bowel, foreign to the normal, it is commonly stated on the evidence just related that a histamine like substance is present in the obstructed bowel, the absorption of which gives rise to toxic symptoms.

In order to appraise the significance of the possible presence of histamine in the obstructed gut, Wangensteen and Loucks (1928) injected 50 to 100 milligrams of histamine dichloride into the lumen of isolated segments in the duodenum as well as ileum of dogs with obstruction of forty eight hours duration. Blood pressure tracings were made to test for the absorption of histamine. No fall in blood pressure attended the injection of these doses of histamine into the bowel of one normal and seven obstructed dogs. The employment of varying grades of increased intra-enteric pressure failed to elicit the physiologic response of histamine absorption as reflected in the blood pressure. When, however, a few cubic centimeters of the loop content were injected into a mesenteric or systemic vein, an immediate fall in blood pressure occurred. In three additional dogs histamine was injected slowly by the drip method into a mesenteric vein, 0.83 milligrams being injected per minute. There was an immediate and profound fall of blood pressure which continued as long as the histamine was given, and from the effects of which one of the animals failed to recover.

These slow injections indicate that the liver does not detoxify any considerable amount of histamine. The absence of blood pressure drops attending the placement of histamine in an obstructed loop indicates that if histamine is absorbed it is detoxified in going through the bowel wall.

Venous Absorption from the Obstructed Bowel

Sugito (1924) and Scholefield (1927) showed to their own satisfaction that portal blood obtained from dogs in the agonal stages of bowel obstruction was toxic on intraperitoneal injection into mice, whereas normal portal or systemic blood was non toxic. Inasmuch, however, as blood equal in amount to 10 per cent of the body weight of the mice was necessary to obtain positive results it is apparent that the source for error in the method is great. Knight and Slome (1936) report recovery of a toxic substance from the superior mesenteric vein, when the entire gut of a cat was strangulated. McLean and Andries (1912) and Werelius (1922) failed to elicit toxic effects in transfusing normal dogs with systemic blood from dogs with intestinal obstruction. Whipple and his associates (1913) injected intravenously into a normal dog a large dose of toxic material prepared from the mucosa of obstructed animals. Two hours later the whole blood volume of this ill dog was injected into another without making the recipient ill.

Experiments—Carlson, Lynch and Wangensteen (1930) investigated

the potential toxic effect of portal venous blood of dogs dying of intestinal obstruction in the following manner. Six dogs were obstructed by severing and inverting the ends of the lower ileum under aseptic conditions. When it was apparent that the obstructed animal was failing rapidly, the abdomen was opened under ether anesthesia and a large mesenteric vein was divided and the portal blood collected into a 3 per cent solution of sodium citrate. 10 cubic centimeters of this solution being employed for every 100 cubic centimeters of blood. The blood thus obtained was injected into the external jugular vein of a normal anesthetized dog under aseptic conditions and the blood pressure of the recipient was registered by means of a cannula introduced into one of the carotid arteries.

Two other experiments were employed as controls. In one of these 220 cubic centimeters of blood was obtained from the carotid artery of a normal dog and collected in citrate solution. To this citrated blood, 10 milligrams of histamine dihydrochloride was added. In the other control 100 cubic centimeters of a 1 per cent sodium citrate solution was administered intravenously without the addition of blood.

Results—Transfusion of blood from the normal donor, to which histamine was added, resulted in an immediate and protracted drop of blood pressure to about one half of the original reading despite the increase in blood volume, seventeen minutes later, the blood pressure had regained practically its initial normal level. The injection of the citrate solution without the addition of blood resulted in slight elevation of the blood pressure of the recipient.

In all of the six animals transfused with the portal blood of six other dogs dying of simple obstruction, a definite increase of blood pressure was obtained soon after the transfusion was begun. This elevation of pressure was sustained for several minutes and then there followed a gradual decline to the original level. In no instance was there a decrease in pressure following the transfusion of blood. The rise in blood pressure obtained in these experiments is undoubtedly a plethora effect. It is significant that portal blood of dogs dying of intestinal obstruction failed to exhibit the physiologic test for histamine. The addition of 10 milligrams of histamine dihydrochloride to systemic blood from a normal dog when injected caused immediate profound and protracted depression of arterial pressure in the recipient.

The Manner and Degree of Absorption in Obstruction

Though the avenues by which absorption may occur in bowel obstruction are well known it is extremely difficult to ascertain exactly in what manner and to what degree absorption may occur by way of any of these routes. It is possible, however, by the employment of poisons (such as strychnine) and dyes with the aid of processes excluding certain avenues of absorption to gain some information upon this important matter.

Experiments—Sperling and Wangenstein (1935) studied mesenteric venous absorption in the following manner. For the determination of degree and rapidity of venous and transperitoneal absorption, 50 milligrams of strychnine sulphate were injected into the lower ileum of two normal

dogs anesthetized with ether. Convulsions developed in 2 to 3 minutes. In two other dogs in which sodium pentobarbital (nembutal) was employed for narcosis, convulsions were delayed to five and eight minutes (It has recently been shown that barbital derivatives retard strychnine convulsions). In four dogs in which simple ileal obstruction had been established from 24 to 96 hours previously, convulsions occurred 6 to 13 minutes after the injection of strychnine into the obstructed segment. In two dogs, a loop of terminal ileum was completely devascularized by cutting the mesentery, 50 milligrams of strychnine sulphate were injected into each, convulsions were delayed for 8 and 15 hours. In two other dogs, following the injection of strychnine into the terminal ileum with its blood supply intact, the loop was placed upon the abdominal wall, convulsions appeared after 8 to 15 minutes, corresponding roughly in time to that observed when the bowel had been obstructed for 24 to 96 hours.

From these experiments it is apparent (1) that previous simple obstruction delays the absorption of strychnine slightly, (2) that placing the gut in an extraperitoneal position delays absorption slightly, (3) that cutting off mesenteric absorption by devascularization delays absorption considerably, absorption then occurring by the transperitoneal route when the bowel is no longer viable. The experiments indicate that the mesenteric route (probably venous) is far more important for the absorption of strychnine than is the transperitoneal.

The effect of increased intra enteric pressure upon the absorption of strychnine over these routes is apparent in the following. With an intact mesentery convulsions are delayed but occur until an intra enteric pressure of 70 millimeters of mercury is exceeded following which no convulsions are observed for hours. Whereas when loops were devascularized (as just mentioned above) no convulsions were observed in two dogs until after 8 and 15 hours respectively, when similar devascularized loops were distended under 100 millimeters of mercury pressure, convulsions were observed in 3 hours.

How an antecedent obstruction affects transperitoneal absorption (permeability) is apparent in the following. It has been related that when strychnine was injected into devascularized loops convulsions appeared in two dogs after 8 and 15 hours. When two dogs were obstructed for 72 hours and the terminal obstructed segments were devascularized and injected with strychnine, convulsions appeared in 3 and 4 hours.

Experiments similar in practically every particular to all these just related above were carried out on a larger number of cats (thirty eight) with almost identical results. Strychnine sulphate was injected in 10 milligram doses convulsions as a rule, appeared slightly earlier than in the dogs.

In previous experiments relating to the absorption of potassium ferrocyanide from the gut under measured increased intra enteric pressure, it was shown that transperitoneal absorption is correlated fairly directly with loss of viability. It is apparent therefore, that previously obstructed

gut following devascularization becomes non viable and abnormally permeable more readily, than does a bowel whose wall was normal up to the time that its blood supply was cut off

Lymphatic Absorption

The lymphatic absorption of dyes has been studied by a number of workers Stabins and Morton (1929) put colloidal silver into obstructed loops but could not demonstrate its presence in the vessels or walls of viable intestine The dye was found in the lymph stream only when the bowel was perforated Schempp (1928) and Hagan (1931) showed that vital dyes as trypan blue, were absorbed with greater facility from the obstructed bowel of the dog than from the normal

Experiments—Sperling and Wangenstein (1935) studied the lymphatic avenue of absorption in the following manner Controls—In a group of five normal cats an enteric injection of 20 cubic centimeters of 170 trypan blue was made under ether anesthesia At intervals of 2, 5, 18, and 48 hours the abdomen of each cat was reopened There was no evidence of staining of the lymph nodes Recognizing that transport might have been so rapid that absorption could not occur a chemical peritonitis was induced by irritating the visceral and parietal peritonea with tincture of iodine (5 cubic centimeters) in six cats A lethal issue occurred in all between 24 and 72 hours In only one cat were the mesenteric nodes stained

Simple obstruction—Simple ileal obstruction was established in four cats and 20 cubic centimeters of 1 per cent trypan blue was injected into the bowel above the site of obstruction with a fine needle These cats died in 24, 72, 72 and 120 hours respectively The results were negative with the exception of the 120 hour survival, in which cat a few of the mesenteric lymph nodes exhibited blue spots

A similar obstruction was established in ten other cats and 20 cubic centimeters of a 1 per cent solution of gentian violet was injected, four cats were sacrificed at 48, 72, 96, and 144 hours no coloration of the lymph nodes was apparent The remaining six cats were allowed to die of their obstruction death occurring on the average 68 hours later, varying between 24 and 144 hours In two of these, the mesenteric lymph nodes were purple

Closed loop obstructions—In nine cats closed loop obstructions were made in the terminal ileum and 20 cubic centimeters of 1 per cent gentian violet was injected into the loop Four animals were sacrificed at 24, 24, 72 and 72 hours respectively The mesenteric lymph nodes were purple in all instances Five cats were allowed to die of their obstructions death occurring between 24 and 96 hours The mesenteric nodes were purple in three but were not stained in two

Trypan blue was injected into closed loops of three cats The periods of survival in each case were respectively 24, 72, and 72 hours The mesenteric nodes were blue in each instance

Comparison of Lymphatic Absorption from Simple and Closed Loops and the Significance of Increased Intra enteric Pressure

In three of fourteen cats with simple obstruction, the lymph nodes were colored after intra enteric injection of gentian violet or trypan blue. In twelve cats, ten showed coloration of the mesenteric lymph nodes following the establishment of closed loop obstructions.

These results indicate the greater likelihood of lymphatic absorption under the influence of increased intra enteric pressure as exists in closed ileal loops. These findings were corroborated by employing increased intraluminal pressures. In two cats with closed loops first established, the employment of 100 millimeters of mercury pressure following the injection of gentian violet into the loop caused the appearance of the dye in the regional lymphatic vessels of each cat in ten minutes, 50 millimeters of mercury pressure was employed in another cat, and the dye appeared in the neighboring lymph vessels in an hour. In another cat in which a simple obstruction of the terminal ileum had been established 48 hours before, the employment of 40 millimeters of mercury pressure forced the dye to appear in the lymph vessels in 30 minutes.

These observations are in accord with the well known physiological principle that increases of venous pressure enhance the rate of lymph flow. The appearance of the dye in the lymph vessels of cats with simple obstruction that were allowed to die of their obstruction and failure of the mesenteric nodes to be stained in animals with simple obstruction that were sacrificed are readily understandable in that lymph flow continues after death (Drinkler and Field (1933), Bainbridge (1906)).

The Influence of Obstruction upon the Lymphatic Absorption of Bacteria

A number of investigations show that bacteria may be isolated occasionally from the mesenteric lymph nodes under presumably normal conditions. Adam (1914) obtained positive cultures of intestinal bacteria from mesenteric lymph nodes of apparently healthy animals. Shuger and Arnold (1931) recovered *Bacillus prodigiosus* organisms from mesenteric lymph nodes following their introduction into the rectum of animals. David and McGill observed that trauma or obstruction of the colon caused an increase in number of bacteria in the mesenteric lymph nodes.

Experiments—A few mesenteric lymph nodes were excised for preliminary culture from several cats, all proved negative. A heavy suspension of *Bacillus pyocyaneus* was then injected into the ileum of six of these same cats. Cultures were then taken from these nodes one hour after the introduction of the pyocyaneus organisms, in two instances positive cultures were obtained, four were negative. Two of these four latter animals however, yielded positive cultures when reoperated upon after 24 hours. In two additional cats, previously obstructed, the intra enteric injection of *Bacillus pyocyaneus* under increased pressure resulted in finding the organisms in the mesenteric lymph nodes after one hour in both instances.

Similar experiments were performed upon normal and obstructed dogs.

Control cultures of lymph nodes made before operation on nine normals were negative for bacteria. Following the introduction of *Bacillus pyocyaneus* into the ileum of nine normals, two gave positive cultures of the mesenteric lymph nodes. In six dogs with low simple ileal obstruction varying in duration from 24 to 96 hours, all were positive on subsequent culture. Cultures of the thoracic duct lymph in five normals and six obstructed dogs after intra enteric injection of *Bacillus pyocyaneus* were negative for the presence of the organisms. Cultures of femoral and portal blood were also negative. Williamson and Brown (1923) had previously found negative cultures in the thoracic duct lymph of normal dogs after the introduction of *Bacillus prodigiosus* into the intestine. Murphy and Brooks (1915), however, found a toxic material present in the thoracic duct in obstructed cats.

An attempt was made to evaluate the significance of the absorption by interruption of lymphatic absorption. This was done by ligating or cutting the lymphatic pedicle in the mesentery. Following execution of this procedure in several cats the survival period was not prolonged.

E THE SIGNIFICANCE OF THE BLOOD LOSS FACTOR IN STRANGULATION OBSTRUCTIONS

In some experiments described above, it was found that no evidence of histamine absorption could be demonstrated following its intra enteric injection into dogs with obstruction of the duodenum or ileum. Histamine was injected similarly into a loop of small bowel strangulated with a tape ligature tightly tied in two dogs. When the ligature was loosened, there was an immediate and protracted fall of blood pressure, when the ligature was tightened, the pressure rose. At first, this occurrence was construed to indicate that the injury of the bowel wall attending constriction of the gut and its mesentery allowed histamine to be absorbed by way of the mesenteric vessels when the ligature was loosened. It was soon observed, however, that when the injection of histamine was omitted (in six other strangulations) loosening of the ligature brought about a similar fall in pressure which was gradually corrected by tightening the tape ligature. These results then appeared to indicate the occurrence of a toxic effect from absorption of autolyzed intestinal mucosa especially inasmuch as preliminary meticulous washing out of the content of the strangulated loop in two dogs failed to prevent this drop in pressure attending release of the intestinal ligature. (Wangensteen and Loucks 1928)

When primary resection was performed in a group of dogs, (Wangensteen and Houkom 1928), 4 to 6 hours after the establishment of strangulating obstruction, by the application of a loose ligature, recovery followed in the majority of instances. In another group of dogs, similar strangulating obstructions were established. After 4 to 6 hours, the tape was loosened and the bowel, appearing viable, was allowed to remain. This procedure was followed by a considerably greater loss of animals than occurred in the group in which primary resection was done. This occurrence suggested two likely explanations (1) that excision of the strangulated gut arrested hemorrhage or (2) that excision of the strangulated

gut precluded continued absorption from the damaged loop

This deduction was subjected to further experimental scrutiny by Scott and Wangensteen (1932) in the following manner. Similar blood pressure tracings were made on a number of dogs after (1) ligation of the veins to a segment of the gut, (2) ligation of the arterial supply to a similar segment, (3) complete division of the mesentery of the gut cutting both arteries and veins, and (4) encirclement ligation of a segment of gut and its mesentery.

Briefly stated, the results of these experiments indicated clearly that

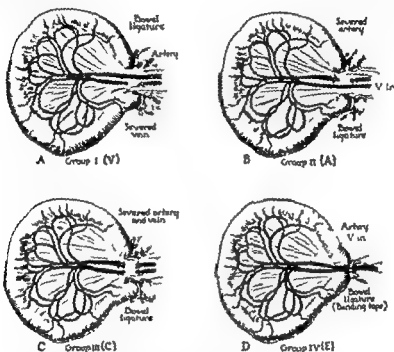


FIG 14—Types of experimental strangulating obstruction. A Encirclement ligation of bowel and vessel. B Complete severance of mesentery with ligation of bowel. C Arterial obstruction. D Venous obstruction. Beside the group number is listed the designation employed in Fig. 15 to indicate the blood loss. (Scott H. G. Arch. Surg. 36:816, 1938.)

there was a direct correlation between the manner of interference with the blood supply of the gut, the arterial blood pressure, the length of the segment concerned (particularly in venous obstructions) and the survival time. The ligation of veins (ten dogs) to a segment of small intestine varying in length from 2 to 5 feet caused severe falls in arterial blood pressure which resulted fatally in 2 to 4 hours. In one dog in which the superior mesenteric vein was tied the arterial pressure which had been 140 millimeters of mercury initially, fell gradually and in an hour the dog was dead. The longer the loop the more marked was the fall in pressure and the shorter the survival period.

The results in group two (three dogs) in which the arteries were tied, and those of group three (three dogs) in which both arteries and veins were tied, were very much the same.

Blood pressure tracings continued for 4 to 6 hours showed no significant alteration in pressure. These animals survived for 16 to 20 hours. In two animals, just before death, the arterial pressure was recorded again and found to be low. The most variable results were obtained in group

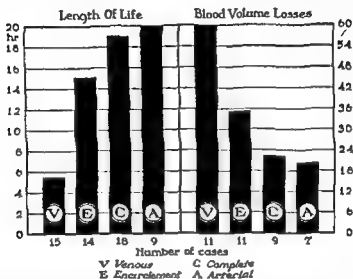


FIG 15—Blood volume losses and length of survival following various types of strangulating obstruction. It is to be noted that the blood loss is greatest in the venous obstructions and the survival time is the shortest in this group. In the arterial ligation group the blood volume loss (20%) represents undoubtedly plasma loss owing to increased capillary permeability (protein content of peritoneal fluid 6%) coincident to death of bowel. Complete division of the vessels imitates the effects of arterial ligation closely. Encirclement ligature (depending on how tightly the mesentery and bowel are tied) may partake of the features of venous or arterial ligation. [Summary of data published by Scott and Wangenstein *Proc Soc Exp Biol & Med* 29:49 1932 and published in extended form by Scott *Arch Surg* 36:316 1933.]

four (sixteen dogs) in which an encirclement ligature was placed about the bowel. Blood pressure tracings were carried over an interval of 3 to 7 hours in each dog. On the whole it may be said that no significant falls in pressure occurred. In six dogs falls in arterial pressure of 30 to 40 millimeters of mercury occurred in this time interval. In the larger number, however, the readings were normal at the end of several hours. In this group one variable in addition to the length of gut concerned was present that did not obtain in the others, viz, the degree of tightness of the encirclement ligature.

It was evident from these experiments that the blood loss factor was the significant item in determining whether an early severe fall in arterial blood pressure would occur. Whether the arteries alone or the arteries

gut precluded continued absorption from the damaged loop

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Briefly stated, the results of these experiments indicated clearly that

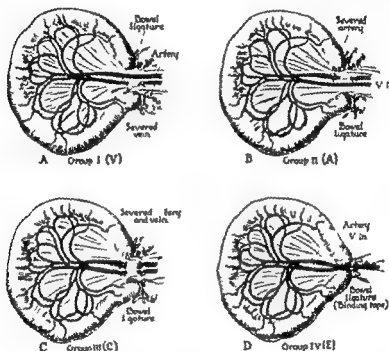


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The hemoglobin content of the blood tinged peritoneal cavity in these instances averaged a little less than 1 per cent. Protein determinations made on the peritoneal fluid, however, showed it to be not unlike blood plasma. Calculated on this basis, despite the fact that the actual blood loss was not great in the instances in which the arteries were tied, it could still be contended that the blood volume loss was significant and averaged about 20 per cent. Scott (1938) has elaborated upon these observations.

Comment—The experiments indicate that the blood loss factor is significant in strangulating types of obstruction, particularly where the venous obstruction factor predominates. Pure forms of arterial obstruction are to be seen clinically, probably only in instances of arterial thrombosis or emboli in venous thrombosis of the mesenteric vessels, increased intraluminal pressure, in instances in which it becomes great enough to occlude the veins and the various types of torsion, encirclement and invagination of the gut are essentially instances of venous obstructions of varying grade. In all of this latter group, particularly where the segment concerned is long, the blood loss factor may produce actual surgical shock.

It is also apparent that accompanying threatened or actual loss of viability of the gut, abnormal permeability and transperitoneal absorption may occur. In the arterial obstruction group which survived for 16 to 20 hours this undoubtedly was the chief factor in the cause of death, the greater number of these segments deprived of arterial blood being found ruptured at necropsy.

The recovery of a fluid with a 6 per cent protein content from the peritoneal cavities of dogs having arterial obstruction alone to a loop suggests that lack of oxygenation had impaired the viability of the bowel wall, permitting abnormal capillary filtration.

The relationship of viability and permeability as related to increased intra-enteric pressure has been discussed previously. These latter experiments afforded an opportunity to determine in what manner interference with the arterial inflow or venous return of blood influences the factors of viability and permeability. These observations (Scott and Wangenstein 1932) have been confirmed since by a number of investigations: Holt (1934), Knight and Slome (1936, 1937), Aird (1937), and Maycock (1938). Observers had indicated repeatedly that strangulating obstructions are potentially more serious than simple obstructions. Murphy and Vincent (1911), Wilkie (1913), Foster and Hausler (1924). Demonstration of the blood loss factor in strangulating obstructions has solved in part the mystery of this occurrence.

Scott and Wangenstein (1932) studied the toxic effect of fluid collecting in the peritoneal cavities of dogs with strangulating obstructions in the following manner:

*Effect of Intravenous Injection of Peritoneal Fluid Attending
Strangulating Obstruction*

In fourteen dogs embracing the various types of interference with blood flow employed, the peritoneal fluid was collected and infused into

and veins together were tied did not appear to make much difference, but when the veins alone were tied, a gradual, but definite and lethal fall in pressure occurred invariably. Death followed ligation of the arteries alone or arteries and veins, to be sure, in 16 to 20 hours, but no significant change in blood pressure was observed until shortly before death. Under the motive force of systolic blood pressure, blood was being forced into the gut wall and lumen of the bowel, the mesenteric vessels being end vessels and egress of the blood being prevented by ligation of the mesenteric veins. hemorrhagic infarction of the gut occurred with considerable loss of blood.

The contrast in gross appearance of the segments of gut, whose blood supply had been interfered with in these various manners was striking. When the veins were tied, the resultant color of the bowel after 3 to 5 hours was a deep purple, and the segment was heavy and distended. The wall was thick, the lumen of the bowel contained dark blood frequently clotted, and the peritoneal cavity contained considerable bloody fluid. The segments in which the arteries alone or arteries and veins together had been tied, manifested similar findings. The segments of gut were all purplish in color, but were not found to be distended and heavy as when the veins alone were interrupted. The wall was thin and extremely friable, and in the larger number the bowel wall was perforated in one or more places. The peritoneal cavity in such instances contained a dark foul smelling bloody fluid, when the segment was not perforated a small amount of blood tinged fluid was found. In group four in which an encirclement ligation had been placed about the bowel findings intermediate between the two types just described were found. Instances approximating the appearance of pure venous obstruction occurred and findings similar to those of pure arterial interruption were observed less frequently.

In order to determine the degree of blood loss in each group, the peritoneal fluid was collected and its protein and hemoglobin content determined. The weight of the segment was ascertained after excision and the amount of blood loss was calculated from hemoglobin determinations made upon the bowel content and peritoneal fluid. The increases in weight of the segments of gut could be fairly accurately determined from a knowledge of expected weights of certain lengths of the normal gut at different levels described in a previous part of this study. Hemoglobin determinations were made by the Sahli method. The blood volume loss was calculated by taking the arbitrary figure of 75 per cent of the body weight as the total blood volume.

The increase in gut weight in group one in which the veins were tied averaged 283 per cent. In groups two and three in which the arteries and veins were tied, there was no increase in gut weight. In group four, in which an encirclement ligation was placed about the bowel the increase in weight averaged 235 per cent. In the latter group the loss in blood volume averaged 35 per cent, in vein ligations alone, the average blood loss was 55 per cent. In the unruptured instances of ligation of arteries alone or together with the veins, the blood loss factor was not so great.

recovered in the first aspiration made from the peritoneal cavity (45 minutes after the ligation of the veins) caused delayed convulsions which appeared in the frog one hour after injection. All injections of subsequently aspirated fluid proved negative, however.

The Bacteriology of the Peritoneal Fluid Accompanying Strangulating Obstruction

Scott (1938) studied the peritoneal fluid collecting in the peritoneal cavity in strangulating obstructions, in the following manner:

In ten dogs encirclement ligatures of the lower ileum of segments of bowel about 3 feet in length were made. At periods, varying from 3 to 45 hours later the abdomens of the dogs were reopened and specimens were obtained for bacteriological study. The constricting tape was also removed. Cultures were made on lactose liverpeptone and brain media. Smears were then made from these cultures after 24 and 48 hours. A large number of organisms including the following were found: (1) Gram positive spore forming rods, (2) Gram positive micrococci, (3) Gram positive diplococci, (4) Gram negative rods, (5) *Clostridium Welchii*, (6) *Bacillus coli*, (7) *Bacillus aerogenes*, (8) *Streptococcus hemolyticus*, (9) *Staphylococcus*, (10) Sarcina.

In six of these ten cases positive cultures were obtained, four were negative. There were also four deaths, three of the deaths occurred within two hours of the release of the encircling tape, and were undoubtedly due to continued hemorrhage into the gut. One of the deaths occurred in an animal having negative cultures and three recoveries occurred in the group in which the cultures were positive. These findings are in consonance with those recorded by a large number of investigators who have examined the fluid in the sac in strangulated hernias. Bacteria may be present in the fluid even though the gut may survive, that the viability of the gut is threatened or impaired is apparent.

There appears to be no cogent evidence in the contention of Williams (1926) that toxemia due to anaerobic organisms plays an important role in the lethal issue of intestinal obstruction. Haerem, Dack and Wilson (1938) failed to demonstrate B. Welchii toxin in closed intestinal loops in dogs. And McIver and his associates (1929) failed to observe any protective therapeutic value from administration of B. Welchii antitoxin to obstructed cats. Yet undoubtedly in the peritonitis attending late strangulating obstructions in patients anaerobic organisms play an important role now and then.

F THE TOXEMIA QUESTION AND BOWEL OBSTRUCTION

As related previously clarification of the mystery surrounding the cause of death attending high jejunal obstruction did much to lessen focus of attention upon the toxic absorption factor as the primary cause of death in obstruction. Demonstration of the significance of the blood loss factor as an important item in the lethal issue of strangulating obstruction has served to detract also from the former attractiveness of the toxic absorption theory, in interpreting acceptably observed phe-

the leg vein of another normal dog. A tracing of the carotid blood pressure of the recipient was obtained during and for some time following the injection. These dogs were lightly anesthetized with ether during this interval.

Results—A fall in pressure was obtained only in those instances in which the loops had ruptured. Attending the injection of the peritoneal fluid from these dogs a sharp fall of arterial pressure followed. All recipients died the following day. In the remaining ten instances, no immediate or delayed effects attended the injection.

Knight and Slome (1936) collected fluid from strangulated intestinal loops by placing a bag about the loop. They were able to demonstrate, on intravenous injection, the presence of a toxic material, in this fluid. Wahren (1936) and Aird (1937) made somewhat similar observations—their findings indicating too, the presence of a toxic material in the fluid collected in bags, placed about strangulated intestinal loops.

Influence of Arterial and Vein Ligation on Absorption of Strychnine

In ten dogs in which the arterial supply to a segment of gut was interrupted by ligating the arteries, 50 milligrams of strychnine sulphate were introduced into the segment after both ends were tied to prevent absorption from the adjacent healthy bowel. The average survival period was 16.7 hours. None of the animals manifested symptoms of strychnine poisoning during life. Samples of the peritoneal fluid (10 to 20 cubic centimeters) were injected into the peritoneal cavities of four guinea pigs. None developed convulsions. In three instances, 3 to 5 cubic centimeters of peritoneal fluid were injected into the dorsal lymph sac of three frogs; all developed convulsions after 12, 15, and 45 minutes respectively. Strychnine undoubtedly therefore had penetrated the bowel wall even though in small amounts. It was interesting to observe how mere interruption of the arterial blood flow with the avenue for escape through the veins still open, practically does away with mesenteric absorption.

Similar determinations were made upon nine dogs in which the veins to a segment of gut three feet in length were tied. Fifty milligrams of strychnine sulphate were injected into each loop and the ends of the segment were tied to preclude absorption from the adjacent healthy bowel. The average survival period was 8 hours. This figure was made somewhat greater than that previously observed for various obstructions in that one dog survived for 20 hours. The more usual survival period as indicated in the previous series in which the veins alone were tied was 4 to 6 hours. Three of these nine dogs developed convulsions, in six dogs no evidence of strychnine absorption occurred. The loss of blood alone into the infarcted segment is a prominent feature in the cause of death. Peritoneal fluid was recovered in each instance and injected into the dorsal lymph sacs of frogs. In the three animals which developed convulsions, the frog tests were positive. In two of the nine dogs a catheter was placed into the cul de sac and aspirations of the peritoneal fluid were made every 30 to 45 minutes and injected immediately into frogs. All of these injections proved negative in one frog, in the other, the fluid

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nomena attending obstruction, which demand explanation. The recital of observations, which preceded, concerned itself largely with pointing out the importance of mechanical effects of increased luminal volume, pressure and tension upon the permeability and viability of the bowel wall. It is this writer's belief that these are the important items that contribute to the lethal issue in bowel obstruction.

There are, however, a number of recorded observations that bear upon the alleged factor of toxic absorption, which can not be passed over lightly. In the analysis of *how* the toxic absorption occurred, to one accustomed to think along the mechanistic lines, outlined above, the question recurs always: Was there injury of the bowel wall followed by transperitoneal migration of noxious substances?

It is obvious that discriminating data sufficiently precise to answer the query of *how* the toxic absorption occurred, are not always available. It is perhaps fair to say that more and more, experimentalists and critical clinicians are leaning toward the mechanistic conception developed in this discussion. Many have capitulated completely to this view. Bottin (1938) appears to be one of the few, who has concerned himself with experimental aspects of the problem, who clings still to the toxin absorption idea, as constituting a satisfactory explanation for the lethal issue of obstruction.

The demonstration of a fluid with toxic properties, collected in bags or from the peritoneal cavities of dogs with strangulated intestinal loops, has been made by a large number of investigators (Knight and Slome (1936, 1937) Wahren (1936), Aird (1937), Maycock (1938) and others). Maycock demonstrated the presence of histamine and choline in such fluid but believed that the circulatory depression attending strangulating obstructions was not explicable on the basis of absorption of toxic materials from the peritoneal fluid, alone. The blood loss factor, discussed at length in the preceding section has been corroborated adequately by a number of investigators, and is, in many clinical obstructions, as well as in the experimental animal, an item of importance.

Sweet, Peet and Hendrix (1916) went so far as to suggest that the only real hazard from a closed intestinal loop was perforation. Undoubtedly, however, noxious agents can migrate through a devitalized bowel wall, before an actual anatomic break in continuity is apparent.

It is proof of absorption from the lumen, via the mesentery, in simple obstruction that, those like myself demand who affect not to believe in the toxin absorption idea. Chenut (1926) and Morton (1939) appear to compose the difficulties of the situation quite readily by stating that attending prolonged sustained increases of intraluminal pressure areas of necrosis develop in the mucosa of the bowel wall exposing capillary blood vessels, through which absorption may occur. Death of the bowel wall from the mucosa to the peritoneum obviously would permit transperitoneal migration. More detailed studies employing combinations of physiologic and histologic approaches are necessary to settle this question definitely. The following questions appear to bear fairly directly on the issue: 1) To what extent are the submucosa and the circular muscle, each responsible

of anaphylaxis. No evidence of anaphylaxis was observed when unobstructed guinea pigs, sensitized to horse serum, were fed horse serum. This evidence suggests definitely that abnormal absorption occurred, but whether by the mesenteric pedicle or by transperitoneal migration, as a result of injury to the intestinal wall, is not clear.

It is conceded freely by everyone, and, there are a number of experimental observations which suggest that all intestinal content is toxic. Hill and Stoner (1941) have pointed out that the leucopenia, attending intravenous injections of extracts prepared from normal or obstructed intestinal contents, may be employed as an agent to gauge the extent of the toxic reaction. Any attack on the toxic absorption theory, which takes no account of the likely avenues of absorption, evades the most important aspect of the problem.

The closed intestinal loop, employed first by Stone, Bernheim and Whipple (1913) to investigate the formation of toxic proteoses in bowel obstruction, has become an instrument of great value in demonstrating the damaging local effect of increased intraluminal tension. And one of the startling conclusions, forced upon any one who becomes a student of the problem, is the surprising end effects of relatively low pressures, operating over a period of time.

The local end effects, attending sustained increases of pressure in long loops in the presence of simple obstruction, may be summarized as follows:

- 1 Increase in intraluminal content (gas and fluid)
- 2 Increased motor activity of the bowel
- 3 Distension and intestinal stasis
- 4 Thinning of the intestinal wall
- 5 Increases in intraluminal pressure
- 6 Decreased absorption from the intestinal lumen
- 7 Venous stasis in the bowel wall
- 8 Anoxemia
- 9 Impaired viability
- 10 Histologic evidence of local injury to the intestinal wall
- 11 Increased permeability
- 12 Migration of noxious substances through the damaged bowel wall
- 13 Toxemia from transperitoneal absorption

G SUMMARY OF THE EFFECTS OF OBSTRUCTION

It has been indicated by a brief review of the work of a period some what longer than the past decade that the seriousness of high intestinal obstructions is due essentially to the loss of electrolytes and fluid by vomiting, and that the liberal administration of saline solution neutralizes these ill effects and permits the animal to tolerate the obstruction for a considerably longer time. In low obstructions, on the contrary, the loss of fluid and electrolytes is not a prominent feature and saline replacement therapy is not of much value. In the high obstructions, vomiting empties more readily the distended loops, in the low obstructions evacuation of the lower loops is not accomplished readily and the mechanical effects of distension upon the bowel wall become more manifest.

The factors contributing to distension are (1) the alimentary digestive juices which, in adult man, are probably in excess of 7,000 cubic centimeters a day. Under the influence of distension and obstruction, the secretion of alimentary fluid may be increased in amount. (2) The chief source of gaseous distension is swallowed air. This was shown by excluding the swallowed air factor by transecting the cervical esophagus and inverting the distal end. Swallowed air accounts for about 68 per cent of the gas in obstruction of the small intestine, of the remaining 32 per cent, 70 per cent originates by diffusion from the blood into the bowel lumen, the remaining 30 per cent arises through putrefactive activity of intestinal bacteria. The liberal administration of saline solution to dogs with obstruction increases the amount of fluid in the bowel. In the presence of a gut which is dilated because of obstruction despite the exclusion of the swallowed air gas may still find its way into the gut from the blood.

The composition of gases has been determined in a large variety of experimental and clinical types of obstruction. Nitrogen constitutes from 70 to 80 per cent of the gas present in obstruction. Hydrogen sulfide the combustible gases (hydrogen and methane), the volatile basic group (ammonia and the tertiary amines) carbon dioxide and oxygen constitute the remainder in somewhat variable amounts.

The effects of acute obstruction upon the bowel have been studied and it was observed that the bowel shortens usually. In established experimental obstructions, a shortening of 20 to 33 per cent was observed over considerable lengths proximal to the obstruction. When correction is made for this shortening process, an increase in weight of the obstructed bowel of 34 per cent over the normal was found. The bursting strength of obstructed segments of bowel is considerably reduced as compared with the normal (50 per cent).

The sustained intra enteric pressures were determined in a large number of experimental and clinical obstructions. The average sustained intra enteric pressure in dogs with low ileal obstruction was found to be less than 10 centimeters of water pressure. In four patients with obstruction of the small intestine the sustained intra enteric pressure varied between 4 and 14 centimeters of water. In a number of colon obstructions in man, however considerably higher intra enteric pressures varying between 12 and 52 centimeters of water were found. The competency of the ileocolic sphincter and valve makes of the colon a closed loop obstruction with the distinct handicap that in addition the ileocecal valve permits fluid and gas to be poured in from the ileum but precludes regurgitation into the small intestine.

The effects of sustained pressures upon the anatomy, viability and permeability of the bowel were studied. Diffusion of potassium ferro cyanide through the bowel into the peritoneum did not occur as long as the gut wall was viable. Whereas an intra enteric pressure continuously sustained for 27 and 28 hours caused petechial hemorrhage in the bowel wall it was still viable and not abnormally permeable. Similarly an intra enteric pressure of 20 centimeters of water sustained for 10 and 22 hours caused congestion of the bowel, but it was still viable. Pressures of 20

centimeters maintained for 28 and 32 hours caused necrotic patches in the gut and the bowel was no longer viable and permitted the diffusion of potassium ferrocyanide through its wall. Pressures of 40 centimeters of water were tolerated as long as 11 hours, but when longer continued, necrosis of the gut wall with abnormal transperitoneal diffusion occurred.

The results of microscopic studies of the bowel wall in instances of experimental simple obstruction of 3 to 6 days' duration indicate that the congestion observed owes its presence to dilated blood vessels in the gut wall. No evidence of interstitial hemorrhage was observed. No areas of necrosis or mucosal ulceration were found. The findings were limited to edema, and shortening and clubbing of the villi.

In addition, the systemic effects of increased intra enteric pressure, described above, are not to be ignored. Segregation of blood in the lower extremities occurs apparently with ensuant reductions in effective circulating blood volume.

The effects of obstruction and distension upon absorption were studied. An 18 inch loop of lower ileum absorbed, in an hour, 87 per cent of the water necessary to fill it, whereas in similar previously obstructed loops only 9 per cent was absorbed. No evidence of histamine absorption was obtained from viable segments of obstructed bowel. No toxic effect was obtained on transfusing the entire return flow of blood from the superior mesenteric vein of dogs exsanguinated in the terminal stages of simple obstruction into normal animals. No depression of the arterial pressure was observed in the recipients. In the event that histamine was absorbed from these obstructed segments of bowel, it was detoxified in going through the bowel wall, for slow injections of 0.83 milligrams of histamine dichloride per minute into a mesenteric vein caused a profound and protracted depression of blood pressure.

Strychnine sulphate is absorbed somewhat more slowly from obstructed segments of bowel of the dog and cat (6 to 13 minutes) than from the normal (2 to 3 minutes), placing loops in an extraperitoneal position delays absorption slightly also (8 to 15 minutes). Devascularizing the intestinal loops into which the strychnine was placed delayed the appearance of convulsive phenomena for 8 to 15 hours. When the intra enteric pressure was tremendously increased in normally vascularized loops no evidence of strychnine absorption was observed in viable loops until the intraluminal tension was reduced to 70 millimeters of mercury pressure. When, however, an intra enteric pressure of 100 millimeters of mercury pressure was employed in devascularized loops into which strychnine had been placed, convulsions appeared in three hours, indicating that transperitoneal diffusion had occurred.

Lymphatic absorption of trypan blue and gentian violet is enhanced and accelerated by obstruction. Increases of intra enteric pressure, of a grade that causes venous stasis, augment absorption by the lymph vessels. Obstruction of the bowel facilitates the absorption of bacteria into the mesenteric lymph nodes. *Bacillus pyocyaneus* introduced into obstructed loops of cats were recovered from the mesenteric lymph nodes but not from the thoracic duct chyle. Severance or ligature of the mesenteric

pedicle in obstructed cats, in order to obviate lymphatic absorption, did not increase the survival time

In a study of the effect of strangulation upon the bowel, it was found that the occlusion of veins permitted the loss of considerable blood into the wall and lumen of the strangulated segment. When the veins alone were tied to a segment 3 to 4 feet in length enough blood was lost in 4 to 5 hours to produce shock and frequently death. When the arteries and veins together or the arteries alone were tied the survival period was considerably longer (16 to 20 hours) and though fluid of a high protein content accumulated in the peritoneal cavity, the blood loss was not great. Accompanying arterial ligation, there was no gain in weight of the gut, but when the veins alone were tied the average increase was 283 per cent and due largely to the leakage of blood into the gut wall and bowel lumen, in consequence of the venous obstruction.

The fluid accumulating in the peritoneal cavity following interference with the blood supply of segments of bowel was found to be non toxic on intravenous injection into other dogs except when the segments were perforated. Of ten dogs with encirclement obstruction bacteria were found in the peritoneal fluid in six instances. Three of the six recovered after release of the constricting tape.

When strychnine sulphate was placed in the gut following ligation of the arterial supply no evidence of strychnine absorption occurred during the life of the animal which averaged 16.7 hours in ten dogs. Injections of peritoneal fluid however into the dorsal lymph sac of frogs gave proof of diffusion of strychnine into the peritoneal cavity in a few instances. In three of nine dogs in which the veins to a segment of bowel three feet in length were tied evidence of strychnine diffusion through the bowel wall was obtained in the occurrence of convulsions in the dogs and similar convulsive phenomena in frogs following dorsal lymph sac injections of samples of the peritoneal fluid. The increase in tension in a non viable gut wall is responsible undoubtedly for accelerating the diffusion of strychnine through the bowel wall in this venous obstruction group as contrasted with its slow diffusion through the devitalized bowel wall of arterial obstruction.

Conclusions—The results of these studies emphasize the significance of the mechanical factors in the development of the ill consequences of obstruction. Apart from the loss of essential fluids which constitutes an important element in high obstructions alone the chief factor of concern is the viability of the bowel wall whether threatened by increase of intra enteric pressure or by external constricting agents. The importance of swallowed air in initiating distension and its effects is demonstrated conclusively in the esophagostomy experiments on the dog described previously in which accretion of distension through this source is precluded. Transperitoneal diffusion or absorption apparently occurs only through a bowel wall whose viability is seriously compromised. When the bowel wall is viable all absorption from the gut except through the lymphatic channels is diminished by increased intra enteric pressure. High intra enteric pressures which jeopardize the circulation of the bowel,

regularly attend acute clinical cases of obstruction of the colon in man. The sustained intra enteric pressures observed in obstruction of the small intestine of the dog and in clinical cases are not great, but of the order of magnitude of about 10 centimeters of sustained water pressure, which if long continued cause histological changes in the mucosa of the bowel. These relatively low pressures have their explanation in the ability of the bowel to accommodate itself to various grades of distension, without great alteration in intra enteric pressure, made possible in the small intestine by the participation in the distension of a considerable length of gut. The lower segments of a long stretch of distended small intestine, can not, however, escape the effects noted in closed loops, in the dog, in which sustained increases of intraluminal pressure are maintained.

What Are the Probable Lethal Factors in Obstruction?

The papers of Cooper (1928), Morton (1939) and Besser (1940) should be consulted for a comprehensive discussion of the many factors involved.

Though no direct and unequivocal answer has been obtained for this very pertinent question, the results of this study permit formulation of the following propositions:

Apart from the loss of fluids and electrolytes which are of serious consequence in high obstructions alone, the chief effects of obstruction are mechanical and concern intra enteric pressure as related to absorption and viability of the bowel. Though it has been shown that intra enteric pressure increases normal lymphatic absorption, there is no evidence that abnormal lymphatic absorption occurs. To be sure, dyes are absorbed when the bowel is obstructed, but an important factor in their failure of absorption normally is that, they do not remain long enough to permit of absorption. Also, bacteria are absorbed through lymphatic channels under conditions of obstruction, but their presence has been demonstrated in mesenteric lymph nodes in the absence of obstruction. But what is more important, neither bacteria nor dyes were recovered from the thoracic duct. Every available evidence points toward a diminution of mesenteric venous absorption with increased intra enteric pressure. Just how an edematous mucosa may affect mesenteric venous absorption is not wholly clear. Observations made on patients with high grade simple obstruction of both the small intestine and colon, subsequently to be recited indicate that as long as the peritoneal coat of the gut is intact—that is, as long as the bowel is viable, transperitoneal absorption does not occur and the patient remains in good condition. The results of this experimental inquiry are wholly in accord with those clinical observations and indicate that the chief lethal factor in simple obstruction is permeation of a gut wall whose viability has become impaired, by bacteria and other deadly agents. In strangulating obstructions apart from the blood loss factor, this too is the chief concern. It would in consequence appear that the rationale of well directed therapy should be reduction of intra enteric pressure by decompression or release of the obstructing agent before the viability of the bowel is impaired.

In the judgment of the writer, the mechanistic conception of the ill

consequences of obstruction provides better interpretation and a more acceptable explanation, of the phenomena and end effects which attend bowel obstruction than does the toxic absorption theory

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PART II

GENERAL DIAGNOSTIC CONSIDERATIONS IN THE RECOGNITION OF BOWEL OBSTRUCTION

CHAPTER II

DIAGNOSIS IN ACUTE ABDOMINAL DISORDERS

A THE MAKING OF A DIAGNOSIS

EXPLORATORY laparotomy has been long in many hands, a favorite and frequent means of establishing the diagnosis in acute abdominal lesions. So general has this practice become that operations for "acute abdomen" have been the order of the day. "Acute abdomen" and necessity for operative intervention have been regarded commonly as synonymous. Such a dictum served to lend the impression that many of the pre-operative deliberations concerning the probable nature of the lesion present were purely philosophic exercises of but little practical value. A natural consequence of this appraisal contributed also to the feeling that the corrective measures employed by the surgeon were responsible largely for the patient's recovery. And if the patient died, it was because of the nature of his illness. The fallacy of such logic is not difficult to detect. Nevertheless, the unwary surgeon as well as the physician who deals with disease and its vagaries are very likely to fall into this pitfall. Rationalization on inadequate or incomplete data is predestined to lead to erroneous conclusions.

Features of bowel obstruction (employing the term obstruction in the broad sense of intestinal stasis) are related so intimately to many acute abdominal diseases that it would appear proper to discuss here in a general way the diagnostic measures which are of value in the formulation of an opinion in acute abdominal disorders.

The making of a diagnosis embraces essentially two items: (1) the taking of evidence and (2) the interpretation of that evidence. The sources for evidence are three in number: (1) the history, (2) the physical examination, and (3) laboratory data. All are important. In an uncomplicated duodenal ulcer the factual data most valuable for the final decision are obtained from the history and the laboratory information, particularly the x-ray observations. The physical examination in this disorder reveals frequently no tell tale signs. In acute abdominal lesions very significant data are obtained almost invariably from the physical examination. Incomplete history taking and perfunctory physical examinations are to be avoided studiously in every case. Laboratory aids are of great worth in the solution of many diagnostic problems, but extremely few diagnoses, however, can be made with their aid alone.

In order to take evidence well it is necessary that the examiner know well the course or the natural history of the disease under scrutiny. In addition he must know the various diseases which may give rise to a train of symptoms or a group of findings similar to the entity which is believed to be present. Armed with this knowledge and mindful of the importance of method and possessed of the requisite experience to pass a mature opinion upon the evidence, the examiner will, in most instances arrive at a fairly accurate judgment. So often in clinical medicine the case under consideration does not readily fit any of the classic descriptions of typical disease entities. In such instances judicious weighing and sifting of evidence are of paramount importance. The determination of what the salient features in the case are and their final integration, in the manner which will adequately account for the clinical picture and at the same time satisfy the opinion arrived at are exercises involved in every diagnosis. In the taking of evidence, the keynote of success is *knowledge* coupled with the virtue of *method* in the interpretation of the evidence the wisdom which comes from *experience* when founded on the rock of adequate *orientation*, is sovereign.

In the making of any diagnosis the examiner will do well to put to himself the three following questions: if satisfactory answers can be secured to the first two, a fairly reliable answer for the final and most important one will probably be reached also. (1) What is the functional disturbance present? (2) What is the anatomy of the lesion? (3) What is its pathological nature?

II THE HISTORY

There are times when a patient with an acute abdominal lesion is so ill that the examiner can not with good grace and a clear conscience ply the patient with questions until relief from his distress has been obtained. If a reliable informant is available the pertinent facts may be obtained from him; if not a careful examination of the abdominal findings should be made after which the patient's distress may be safely assuaged with morphine. The danger lurking in securing relief from distress with opiates before the physical findings have been noted is apparent and has been emphasized abundantly. In the instance of children the information must come second hand frequently and in infants regrettably the history is but an interpretation of what the parents or nurse observed.

In the main the patient's complaint is the best lead to follow out in ascertaining the nature of an illness. Not every patient with a complaint has a demonstrable disorder and in an occasional instance the complaint may not be related directly to the illness which final adjudication decrees to be present. It is the responsibility of the examiner to determine which complaints are real which may be fancied and which are merely accessory to the disorder.

The matter of first importance is to learn when the patient became sick. In almost every acute abdominal disorder the patient can state definitely the day and hour when his indisposition began. It is significant to know what the first symptom was and whether it has continued to be the main complaint. In most acute illnesses of the abdomen, pain is the first and pre-

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Chills accompanying abdominal pain indicate the presence of an infection and are most frequently observed in the cholangitis of biliary tract infection and pyelonephritis. Their occurrence in pneumonia in which abdominal pain may be concomitantly present or in appendicitis with thrombosis of the mesenteric vessels of the appendix are well known.

Whether there have been antecedent similar attacks of pain should be learned, as well as whether there has been any previous indisposition owing to lesser disability. Whether the distress has had any uniform time relation to ingestion of food, if eating relieves or aggravates the distress. Whether the patient feels better on an empty or full stomach or when there is some food in it, whether the distress comes shortly after eating or only after an hour or two. These inquiries help to orient the examiner in the nature of the illness. Flatulence and distress shortly after eating are common accompaniments of biliary tract disease. The mechanism of this occurrence is not understood well. The distress of ulcer is usually relieved by the intake of food. A patient who has complained of occasional twinges of pain which he has interpreted as gas pains, and, who states that his abdomen is noisy frequently and that, he can feel elevations upon his abdominal wall now and then, at the time of gas pains—such a patient is likely to have a stricture in the bowel.

Nausea and Vomiting

Nausea and vomiting attend acute abdominal disorders frequently and appear early usually. The occurrence of vomiting in itself is therefore of no great consequence. Its relation to other elements of the story, however, when properly integrated, gives useful information. The features of vomiting and the character of the vomitus are to be determined carefully. Frequent and copious vomiting speaks for gastric and intestinal stasis. If the vomitus be of a brownish yellow color or feculent and crampy intermittent pain is present also, it is almost certain that the patient has mechanical obstruction of the bowel and in all likelihood, of the small intestine. As has been pointed out already (page 30) in obstruction of the colon vomiting is frequently absent altogether and there is no gastric retention usually as determined by the duodenal tube. Vomiting accompanied by fairly complete relief of distress is suggestive of gastric retention due to pyloric obstruction. However, curiously enough, pyloric obstruction does not give rise to true pain as do obstructions anywhere else in the intestinal canal. Neither does the patient with obstruction to the efferent loop, after gastroduodenostomy or gastric resection, exhibit evidence of intestinal colic. In this instance the reason is apparent. It is not the afferent loop but the stomach in which the retention occurs largely—the stomach being very dilatable. Nausea and vomiting occur usually before the pain attending muscle stretch, becomes evident. The patient with regurgitant vomiting occasioned by obstruction of the small bowel feels better usually after evacuation of the stomach but the crampy pain owing to the obstruction continues. The patient with reflex vomiting occasioned by appendical, biliary, or renal colic experiences no relief after vomiting usually. The vomiting early in obstruction may be reflex in

dominant symptom throughout. Now and then, however, as in appendicitis there may be anorexia or an indeterminate indisposition of a few hours duration before pain begins. When the illness has its origin at night and the patient has gone to bed feeling well, pain is the invariable first complaint except in those disasters where hemorrhage is the underlying fault.

Pain

The character, location, constancy, and radiation, if any, of pain are all significant. Whether tenderness accompanied the pain and was immediately apparent or only came later, as well as its extent must be inquired into. The disability caused by the pain and whether the incapacity was great and immediate or has increased since the onset are important to determine. What the patient did, if anything to seek relief from his distress, whether he continued to work, went to bed, walked the floor, rolled about or lay prostrate and anxiously quiet, when the malady seized him, tell the examiner much about the nature of the disorder.

Appendical, bowel, biliary, and renal obstructions give rise to an *intermittent crampy pain*. The *remission of the colic is of variable duration, lasting usually for several seconds to a few minutes*. In lesions that assume the character of an inflammation with the elapse of time, there is usually as well a constant distress between the colics. The distresses occasioned by the various acute abdominal ill- do not lend themselves well to comparison. The most agonizing type of pain is probably observed in perforation of an ulcer of the stomach or duodenum, the pain of pancreatic necrosis approaches that of perforation in severity. Both of these afflictions give rise to a constant type of distress, often so severe that its sufferer can not adequately describe it. The discomfort provoked by biliary or renal colic probably comes next in order of intensity. The nature of the pain in bowel obstruction is familiar to all who have suffered intestinal colic from whatever cause, and is described usually by the patient as a gas pain. In strangulating obstructions because of the concomitant peritoneal irritation, there is pain also between the seizures of intestinal colic, which does not let up. A dissecting aneurysm of the aorta may cause severe abdominal pain. Simultaneous pain in the lower extremities, because of an inadequate blood flow or diminished or absent pulsations in their vessels helps to identify the nature of the catastrophe.

All colics, having their origin from an intraperitoneal viscus, may be referred to the mid abdomen. The kidney, which develops from a lateral *anlage* is characterized usually by pain in the flank from the start. *Shoulder pain in intraperitoneal lesions signifies irritation of the diaphragm*. In perforation of the stomach, it may occur early. In a strangulated ovarian cyst it usually occurs after the colic has ceased and signals the escape of considerable sanguineous fluid into the peritoneal cavity. Biliary and renal colics apparently are the only acute abdominal afflictions which commonly have typical pain radiations. In biliary colic it is into the back at a spot below the tip of the scapula and to the right of the spine. In renal colic, it is into the corresponding groin and in males, frequently complain of pain in the right testis.

suggest the necessity of a careful examination to see whether evidences of pregnancy are present. When inspection of the cervix and vaginal walls and palpation fail to give decisive information, the Aschheim Zondek or the Friedmann tests for pregnancy should be made. The frequency of painful cramps attending menstruation constitutes a deterrent to attaching the same significance to low abdominal pain in women as in men. In consequence, the warning of pain in acute affections of the lower abdomen is more likely to go unheeded in women.

C THE PHYSICAL EXAMINATION

The criteria of value in the physical examination of the patient with an acute abdominal lesion are the same measures found useful in the recognition of diseases in other parts of the body. These are inspection, palpation, percussion and auscultation. In addition digital examination of the rectum and vagina frequently afford helpful information.

General Condition

Ascertainment of the general status of the patient with an acute abdominal disorder is often the matter of first concern and demands inquiry frequently before the details of the story are elicited. The patient's general appearance, the state of his nutrition, his countenance and the expression of the eye, the color, moisture, warmth, and turgor of his skin, the quality of the pulse and the character of the respiration are significant matters which serve to orient quickly the seasoned examiner concerning the general condition of the patient. The necessity for a general examination embracing careful scrutiny of the heart and lungs, the blood vessels including determination of the blood pressure, the superficial lymphatic system, the extremities and back, the body orifices, and a test of the reflexes and sensation are quite obvious. These investigations must be made as incidents in the physical examination by all practitioners of medicine who essay to pass on the general status of patients. There is great danger in the special examination when its findings are not related to the examination of the patient as a whole.

A composed face affords the examiner considerable reassurance. Still behind the mask of a stoic men much may be hidden. The agony of the patient with severe abdominal pain is usually evident upon his face. The wrinkled and furrowed brow, tense features and drawn lips which may conceal clenched teeth speak as plainly as an inner voice. A pallid face with beads of perspiration lend involuntary confirmation of the patient's distress. Periodic tranquil relaxation informs the examiner that the pain is intermittent and colicky in nature.

The Temperature

Only distinctly bacterial invasions as occur in inflammatory affections such as salpingitis of the Fallopian tubes and pyelonephritis are accompanied by definite and consistent early fever. After the elapse of time and contingent upon how the local disturbance (frequently obstruction as in acute biliary, renal, or appendical colic) has favored the occurrence of

nature too, but then it has the character of gastric or bilious vomit. It is the occurrence of stercoraceous vomit which attaches special significance to the presence of crampy abdominal pain. Experience with the employment of suction applied to an intubing duodenal tube has taught that vomiting after abdominal operations is due essentially to retention in the stomach and upper reaches of the intestinal canal. Keeping the stomach and duodenum empty by continuous suction renders the occurrence of such postoperative vomiting very unusual.

Urination

Whether there has been abnormal frequency of micturition and whether it has been painful must always be inquired. A cul de sac abscess or inflammatory process in the vicinity of the urinary bladder may give rise to frequent urination. The painful features of the frequency as occur quite regularly in urethral, vesical, or ureteral lesions, however, are often absent when the irritation is provoked by lesions extrinsic to the urinary tract. The occurrence of hematuria is of particular localizing value. Save for the unusual case of hematuria occasioned by an inflammatory lesion in juxtaposition to the ureter or bladder, gross blood in the urine identifies the lesion as being present in the urinary tract. In suppuration of the appendix overlying the ureter, hematuria, from extra urinary tract lesions, has its most frequent cause among acute abdominal disorders.

The Bowels

Diarrhea is provoked more often by the self administered remedies employed for the relief of distress in acute abdominal disorders than by the disorder itself. It occurs particularly in instances of enterocolitis, which condition, because of the occurrence of *intestinal colic*, may simulate mechanical bowel obstruction. Occasionally diarrhea is observed in appendicitis. More commonly in acute abdominal conditions there is obstipation of some degree. Accompanying the intestinal stasis which is common to many acute lesions, distension occurs, and the giving of an enema to try to evacuate the bowel is not an uncommon first home remedy. It is always well to inquire whether cathartics or enemas have been administered. Both are pernicious practices. In a tubal pregnancy a hematoma in juxtaposition to the pelvic colon may give rise to pain on defecation. An experienced nurse suggests not uncommonly the presence of a cul de sac abscess when during convalescence after an operation for suppurative appendicitis, a febrile patient feels a frequent urge to empty the bowel and only mucus comes away.

Menstruation

Whether any menstrual irregularity of time or flow is present, it is particularly important to know in all painful afflictions of the lower abdomen in women. The possibility of *ectopic pregnancy in women of child bearing age* must always be kept in mind. The premature or delayed occurrence of menstruation, commencement, cessation and recurrence of menstrual bleeding, as well as *scant or excessive flow*, are significant and

in the pelvis over the course of the iliopsoas muscle, as in a large perinephric abscess occasions the patient to lie not infrequently with the thigh of the corresponding side acutely flexed at the hip joint, the knee is also maintained flexed to support the thigh in that position. In the main inspection of the abdomen is not of the same significance in the recognition of acute abdominal disorders as it is in abdominal swellings or tumors which accompany acute lesions only occasionally. The most valuable evidence obtained from inspection concerns the presence of both com-

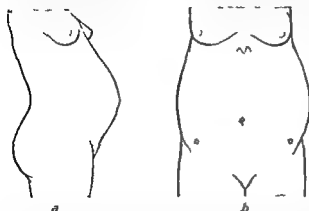


FIG 16—The contour of the abdomen in intraperitoneal tumor and ascites (a) A large intraperitoneal tumor causes protuberance of the anterior abdominal wall (b) In ascites the abdomen is broad due to the collection of fluid in the flanks (*Practitioner's Library of Medicine and Surgery* D Appleton Co 4708 1934)

ponents of respiration. In disorders which effect an intense rigidity of the abdominal muscles, the diaphragmatic component of respiration may be ablated completely. In such instances the breathing is frequently entirely thoracic in character. In the lesser splinting of the abdominal muscles attending lesser grades of abdominal rigidity no visual evidence of disturbed respiration is observed usually, although it

may be noted that the frequency of respiratory excursions may be quickened while their depth is decreased.

Inasmuch as the accumulation of fluid in the peritoneal cavity comes into question not infrequently even in acute abdominal disorders it is well to speak of it here. In a patient whose abdomen is enlarged from either the presence of free fluid (ascites) or an intraperitoneal tumor such as a cyst or solid tumor inspection furnishes frequently the best evidence in this differentiation. Instances have come to the writer's attention in which the diagnosis of ascites has been made as the cause of abdominal enlargement after thorough examination and study when careful inspection alone serves to indicate either that the fluid was encysted or that a solid tumor was present. Ascites gives a broad abdomen which bulges in the flanks. A large cyst or tumor protrudes the anterior abdominal wall. In the adipose abdomen of a corpulent individual this difference may be difficult to detect. The most striking illustration of this contrast is afforded by the prominent protuberance of the nulliparous pregnant abdomen near term when compared with the broad abdomen with bulging flanks of the patient with marked ascites from cardiac failure (Fig 16). Tenting of the anterior abdominal wall is a fairly reliable sign of a large pancreatic cyst.

An intraperitoneal tumor which lies in the upper abdomen the outline

infection or upset the general bodily functions, fever is usual in most acute abdominal disorders. A temperature of 101°F , occurring early at the onset of an illness whose origin would appear to be in the abdomen, should cause the examiner to suspect the lung or the kidney. If chills have occurred, the bacterial origin of the disorder is certain and bacteria have, in all likelihood, found their way into the blood stream.

The Pulse

In acute abdominal disorders generally, apart from those conditions in which considerable hemorrhage occurs, the pulse is not much altered. Unfortunately, unwarranted zeal for graphic description of a picture has, now and then, occasioned observers to give more attention to the form of their description than to careful observation of what they noted at the bedside. And the more it is to be regretted that it is these graphic descriptions frequently which find their way into textbooks. When writers of texts will cease to copy these oft repeated errors and confine themselves to matters of their own knowledge and experience, many of these barnacles will be deleted from our surgical texts. In the experience of the writer, even such a tragic occurrence as an acute perforation of a duodenal ulcer is not accompanied by material quickening of the pulse. Later, in the course of every acute abdominal disorder, the behavior of the pulse is gauged by the general effects of the lesion upon the body economy. Peritonitis, accompanied by an increased permeability of the vascular bed, causes hurrying of the pulse invariably.

The Blood Pressure

The profound prostration which may attend a catastrophic abdominal disorder may lend the impression that shock is present. As with the pulse, it may be said, here too, that depression of the arterial blood pressure, without which true shock does not occur, is not seen early in acute abdominal ills, unless hemorrhage is present. In perforated ulcer, the pulse, blood pressure, leucocyte count, and temperature remain usually within a range bordering on the normal for a period of several hours. On the whole, quickening of the pulse is present usually before blood pressure falls are in evidence. A very rapid pulse is followed almost invariably by a blood pressure which tends to fall to the shock level.

The Examination of the Abdomen

Inspection—The abdomen is best inspected in the presence of good light—the patient lying supine, while the examiner looks across the abdomen toward the light. The attitude of the patient in bed frequently yields valuable information. The patient who complains of colic not uncommonly writhes about, finding it difficult to lie still, the patient whose parietal peritoneum has been irritated by the escape of content from the upper intestinal canal, by exudate from an inflammatory focus or by intraperitoneal hemorrhage lies very still usually and anxiously avoids any movements because it aggravates the distress. Accumulation of pus

insinuated to a greater depth, then the hand is withdrawn quickly. If there be any irritation of the parietal peritoneum over any extent, twinges of pain will be complained of and tenderness elicited. This is the most delicate and reliable test of the presence or absence of peritoneal irritation. Before concluding that peritoneal irritation is not present this maneuver (*choc en retour*) should be repeated in all quadrants of the abdomen. Frequently a patient with acute appendicitis will indicate when this test is made in the left lower quadrant that quick release of the hand causes pain over the site of his spontaneous pain on the right side.

Having ascertained the presence of signs of peritoneal irritability, one next proceeds to determine where the greatest degree of rigidity is. This evidence gives more information concerning the probable site of the source of peritoneal irritation than any other criterion of physical examination. Our entire formula of physical diagnosis as it relates to the recognition of acute abdominal lesions, is pyramided upon the significance of muscle spasm and rigidity as the signs of greatest worth in the localization of the irritating peritoneal focus. The examiner then interprets the rigidity in terms of the organs which lie beneath. Not infrequently the skin is found to be hypersensitive over the area of greatest tenderness and rigidity. Gentle brushing of the lanugo hairs may produce an uncomfortable sensation. Pinching of the skin with the finger may produce pain and hyperesthesia may be demonstrated occasionally with cotton or pin prick.

The most profound rigidity of the abdominal muscles observed clinically attends perforation of an ulcer of the stomach or duodenum. The escaped contents of the stomach are extremely irritating to the parietal peritoneum. However dangerous escape of the contents of the lower reaches of the colon into the peritoneal cavity may be this occurrence is not heralded by the dramatic and excruciating pain of ulcer perforation nor by the same board like contraction of the abdominal muscles which accompanies the leakage of gastric juice into the peritoneum. It may be laid down as a rule that rigidity or muscle contraction response is a measure of the quality or severity of the irritant. Intense board like rigidity of the abdominal muscles is synonymous with perforation of the upper reaches of the gastrointestinal canal. Lesser grades of rigidity are observed following the escape of fluid into the peritoneal cavity which attends pancreatic necrosis. Pus, bile, feces, blood, and urine cause corresponding lesser rigidities of the abdominal wall.

Cases have been brought to the writer's attention of patients who died of peritonitis several days following intraperitoneal rupture of the urinary bladder in which instances, it was alleged, no findings were present during life to indicate that there was any irritation of the parietal peritoneum. If the examination of the abdomen be carried out in the manner described at the beginning of this caption on palpation it is the writer's firm conviction that the sudden abnormal appearance of any fluid in the peritoneal cavity would give rise to increased irritability of the peritoneum which would be detected. Ascitic abdomens to be certain are usually not tender. However when ascites makes its appearance suddenly tenderness is present frequently. The writer has observed instances of carcinoma of the

of which can be distinguished in part by inspection, is observed to move downward with respiration, if the tumor is freely movable, this range of motion may be quite wide. Retroperitoneal tumors, as of the kidney, not lying beneath the dome of the diaphragm, are not influenced so much by its respiratory excursions. Whether a tumor, whose contour may be visualized through the abdominal wall is in the peritoneal cavity or in the abdominal wall itself (a rare but an occasional occurrence) may be determined readily in the following manner. The patient is asked to contract his abdominal muscles by blowing, with the mouth closed and the nose held pinched; if the tumor is in the peritoneal cavity, it disappears from view, a tumor in the abdominal wall is made more prominent by this maneuver (Bailey's sign). These observations with relation to tumors as determined by inspection should be corroborated always by palpation.

Visible peristalsis can be made out often, but as will be related subsequently (p 111) this phenomenon is essentially a sign of muscle hypertrophy and accompanies obstructions which have been present for some time. By the same token, visualization of coils of intestine through an abdominal wall of average thickness indicates an obstruction that has been developing gradually. Almost invariably, a story of previous obstructive features can be elicited in such a case, even though at the time of examination, the obstruction may appear to be of recent origin. The writer has observed visible and palpable peristalsis in three patients with spastic obstruction when no actual organic obstruction was found at operation. The block to intestinal continuity engendered by the existing neuromuscular imbalance in the gut wall had undoubtedly in these instances been responsible for the hypertrophy of the muscle of the bowel wall.

Careful inspection of the common external hernial orifices (umbilical incisional inguinal and femoral) should be made in every patient who complains of abdominal pain. Infarcted fat arrested in an umbilical or femoral hernial orifice, presents occasionally as an indurated redness of the skin and may be mistaken for a subcutaneous inflammatory process.

Palpation—The most valuable criterion of physical examination in acute abdominal disorders as a whole is palpation. In the approach to this portion of the examination, it is important in so far as such an attitude can be assumed by an ill patient to have him in a position of repose. It is important that the patient's eyes are closed so that he can not follow or anticipate the movements of the examiner's hand. This precaution and gentle examination are the best means of excluding voluntary rigidity. The mouth should be open, the arms should lie relaxed at the sides, the legs are to be flexed slightly and the knees separated fairly widely and it is well to have a pillow beneath the knees to support them. If pain or tenderness is complained of in only one portion of the abdomen it is well to commence the examination in the opposite quadrant. The examining hand (which must never be cold) is placed gently upon the abdominal wall and mild pressure is exerted. If no tenderness is encountered as indicated by absence of a tightening of the abdominal muscles beneath the palpating hand and a composed facial expression the following examination should be made. The hand is again pressed gently upon the abdominal wall but

tured in the lateral position so that the right side is up, the correct manner in which to make this examination it is evident that gaseous distension of the proximal colon may also produce tympany over the otherwise dull liver. The presence of free gas in the peritoneal cavity, even in small amount, can be detected by careful x ray examination and is a method to be employed regularly where a break in the continuity of the intestinal canal is suspected. Percussion is of real value in distinguishing ascites from cysts or tumors of the abdomen, all of which are dull on percussion. The movement of large collections of free fluid in the peritoneal cavity on change of posture can be demonstrated readily by the shifting of the dull areas. Because the lateral recesses and the pelvis are the lowest places in the peritoneal cavity when the patient lies supine free fluid accumulates at these sites. When the patient is placed in the left or right lateral position, the fluid will gravitate toward the side that is down and tympany may now be demonstrated over the flank that is up where dullness was present before (Fig 17). A full urinary bladder may be recognized in the presence of persistent dullness over the symphysis despite the change of posture. Employment of the urethral catheter will confirm the suspicion.

Auscultation—The chief value of auscultation in acute abdominal lesions relates to determination of whether *intestinal colic* is absent or present. The repeated audition of borborygmi with the stethoscope at the acme of the pain of which the patient complains establishes the pain as being caused by intestinal contraction. To be certain borborygmi or intestinal noises may be heard in other disorders but it is the intimate time relationship between noise and pain which identifies its origin. A noisy abdomen does not therefore indicate the presence of a mechanical obstruction of the bowel; such a finding denotes only the state of activity of the intestine. A silent abdomen indicates absence of peristaltic activity. A noisy abdomen without *intestinal colic* signifies that the bowel is hyperactive.

In peritonitis when distension is great and fluid separates intestinal coils the heart sounds and occasionally even the breath sounds may be heard everywhere over the abdomen (Peters). The rationale is that fluid is an excellent transmitter of sound. In mechanical bowel obstruction, with the collection of considerable fluid in the intestinal coils, this phenomenon

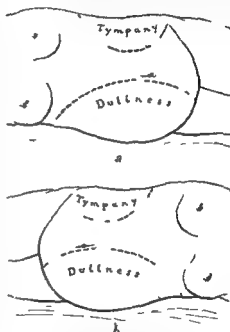


FIG 17—Shifting dullness in the presence of free peritoneal fluid (a) Right side down (b) Right side up

gallbladder as well as of the ovary in which the sudden appearance of fluid in the abdomen, gave rise to a picture simulating that of an acute inflammatory disorder

Another factor which must be reckoned with in interpreting the probable nature of the irritant is the time factor. When, in response to the presence of the excitant, the serosal cells of the peritoneum have had an opportunity to dilute the irritant, the rigidity lessens. When a patient suspected of having perforation of a duodenal ulcer is examined several hours after the occurrence of the disaster, board like rigidity may be absent altogether. Occasionally even as great rigidity may be noted in the right lower quadrant as over the outlet of the stomach. Did not the examiner bear in mind the significance of the immediate and great disability which characterized the onset, he might be misled into believing that the appendix was the source of difficulty. This occurrence has its explanation in this, that after the elapse of some hours attending perforation of an ulcer in the region of the gastric outlet more fluid may have accumulated in the lateral drainage gutter opposite the appendix than near the pylorus.

The parietal peritoneum is probably the most sensitive of all the serous membranes. One need only consider the injection of air into the various body cavities and spaces to appreciate the verity of this statement. The introduction of air into the pleural cavity or into the subarachnoid space of the spinal canal does not provoke usually any particular distress. Pneumothorax may be done on ambulatory patients. Pneumoperitoneum is decidedly a procedure for hospital practice alone. Anyone who doubts the greater sensitivity of the parietal peritoneum may have his skepticism undone by reading an account reported some years ago by Armitage Whitman following a personal experience with pneumoperitoneum. He had his own peritoneal cavity inflated with air to demonstrate more effectually to his confreres who he felt used this procedure more than they were justified, the incapacity which it caused. When Whitman attempted to go home he found it more comfortable to walk on his hands and knees or to stand on his head, so the air would gravitate up against the less sensitive pelvic peritoneum. In the erect posture, shoulder pain was extreme. Clinicians know well that the diaphragmatic peritoneum appears to be the most sensitive portion of the parietal peritoneum.

Rigidity of the abdominal muscles in the absence of tenderness speaks for nerve root irritation such as may be excited by tabes dorsalis or a lesion of the spinal cord and demands a careful neurological inquiry by the examiner.

Percussion—It is to be remembered that the thorax and abdomen would be dull on percussion were it not for the presence of air in the lungs or of gas in the bowel. Percussion will detect readily whether enlargement of the abdomen is due to gaseous distension. It can not be relied upon to determine whether the tympany is caused by general distension of the gastrointestinal tract or by a more localized gaseous distension. This differentiation must be left to x ray examination. Neither is percussion to be depended upon to identify obliteration of liver dullness which may attend escape of gas in perforations of the intestinal canal. With the patient pos-

ing finger is to be noted particularly. When pelvic masses are encountered, it is to be noted especially whether they are tender. An enlarged uterus or an ovarian cyst may be present, wholly apart from the concurrent acute disorder. In *intestinal colic*, the finding of an independent tender pelvic mass is suggestive of a strangulated loop of bowel. Intrinsic tumor masses of the rectum are usually readily identified by this examination.

The simultaneous digital examination of vagina and rectum is useful particularly in the determination of the nature of masses encountered in the pelvis behind the cervix. The examination of these orifices combined with palpation of the lower abdomen with the free hand is particularly useful. Frequently a mass in the lower abdomen, such as an enteric intussusception or a tumor of the pelvic colon, can be brought within the reach of the finger of one of the two examining hands in this manner.

D SPECIAL EXAMINATIONS

Gastric Intubation

In the same manner that the character of the vomitus may constitute an important clue as to the nature of the disease which causes it, so similarly valuable information is gained frequently by gastric intubation. In reflex vomiting retention is rarely great, accompanying pareias of high grade in peritonitis stercoraceous material in considerable amount may be evacuated, in acute obstructions of the colon, the stomach is usually found empty or only gastric mucus or air, are obtained on aspiration. Whereas in mechanical obstruction of the small intestine yellowish brown fluid is recovered whenever the obstruction has progressed far enough to be identified unless the stomach has just been emptied by vomiting. It is extraordinarily important therefore for purposes of orientation, to collect the materials aspirated from the stomach with a suction device in a colorless bottle to permit accurate determination of its character.

Enemas

Employment of enemas for diagnostic and therapeutic purposes is an old tradition. In bowel obstruction the expulsion of gas or feces with an administered enema has been interpreted often as militating against the presence of obstruction. It is not to be forgotten that the bowel distal to the obstruction is not only anatomically but also, usually physiologically normal. Elsewhere Goehl and the writer have discussed this matter at some length. In the main it may be said that in incomplete obstructions particularly deceptive information will be obtained if one is guided by the premise that obstipation is complete in obstructions. In paralytic or inhibitive types of ileus enemas are frequently ineffectual (Fig. 10). Furthermore apart from simple mechanical obstructions of the small intestine the administration of enemata for diagnostic or therapeutic purposes in acute abdominal lesions should be discouraged strongly. In intra-peritoneal suppuration the use of enemas is contraindicated. Several instances have come to the writer's attention in which extension of a localized or localizing inflammatory process attended the administration

may be observed also. The concomitant presence of intestinal colic serves to identify its cause.

Rectal and Vaginal Examination

The natural orifices of the body permit of examination of the organs of the pelvic cavity, which could not otherwise be satisfactorily made. Similarly, in an incisional or para umbilical hernia with a large defect, exploration of the peritoneal cavity is possible frequently within the radius of the finger, aided by pressure of the fingers of the other hand upon the abdominal wall, which maneuver may help to extend the range of the palpating finger. In every acute condition of the abdomen, irrespective of the age of the patient, digital examination of the rectum should be done. The value of the information which may be obtained through it can be fully appreciated only when one is called upon to examine a male patient for an acute abdominal lesion, who has previously had extirpation of the rectum because of malignancy. Vaginal examination is to be done in the instance of every married woman who presents herself because of an acute abdominal disorder. In younger women and children, this examination may be omitted unless satisfactory information can not be obtained by digital examination of the rectum, in any instance in which the findings on rectal examination suggest the necessity for digital exploration of the vagina it should be done.

In the main, the evidence obtained by the examination concerns the absence or presence of tenderness of the pelvic peritoneum and abnormal pelvic masses. In instances in which appendicitis is suspected, tenderness is to be sought and if found compared on the two lateral aspects of the pelvis. The absence or presence of pelvic tenderness as shown by such examination is valuable particularly in differentiating extra abdominal conditions, such as pneumonia with an accompanying pleuritis, which may give rise to tenderness and rigidity of the abdominal muscles from an intra peritoneal lesion. The pelvic peritoneum will not be found tender in pneumonia. It is to be remembered however in lesions of the upper abdomen such as acute cholecystitis or pancreatic necrosis that the pelvic peritoneum on rectal examination may also be found not to be tender.

In the female tenderness elicited on movement of the cervix is to be interpreted as an irritative process in juxtaposition to the uterus. Adnexal inflammation is the most frequent cause though a tubal pregnancy as well as an appendical abscess may also provoke this finding. A stone lodged in the intramural portion of the ureter can frequently be felt on vaginal examination as can as well an infiltrative lesion (malignancy) of the base of the bladder. In the male the condition of the prostate and seminal vesicles is to be noted on digital examination of the rectum. Occasionally an acute seminal vesiculitis, a complication of gonorrhea may be interpreted as appendicitis if this observation is not made carefully. The absence or presence of cul de sac implants, representing remote extensions of an intraperitoneal malignancy should always be noted. An intussusception in an infant may be palpated not infrequently by digital examination of the rectum. The presence of blood or mucus on the glove of the examin-

The Blood

A leucocyte count is made universally as an emergency measure in every acute abdominal affliction. Hemoglobin estimation, red and white cell counts, and a study of a blood smear are desirable in any diagnostic problem. Leucocytosis may be looked upon as a reaction of the bone marrow to infection and injurious influences. A physiological increase in the number of white blood cells accompanies digestion. The total leucocyte count is interpreted usually as indicative of the resistance of the body to infection. The latter count takes cognizance of the fact that immature cells in a blood smear are considered a measure of the severity of the infection. The Schilling hemogram in which the neutrophils are further classified into segmented (mature) forms, stab cells, and juvenile cells and myelocytes gives an even more accurate index of the severity of the infection. The latter count takes cognizance of the fact that immature cell forms are common in the circulating blood in the presence of infection.

Unfortunately, no known means will differentiate absolutely infection from other occurrences which may simulate it. Occasionally leucocytosis may be absent altogether in infection and leucocytosis is usual following trauma after hemorrhage and processes which cause severe dehydration. The blood counts must be integrated into the clinical picture like any other isolated bit of evidence. No therapeutic measure should be withheld or instituted solely on what the blood findings are. In typhoid fever and influenza leucopenia is usual. The rate of sedimentation of erythrocytes is too variable to be of much help in differential diagnosis.

Whether an anemia is due to a chronic blood loss or to a toxic influence the history and special examinations will best differentiate. A careful study of the morphology of the blood will serve to detect a co-existing blood disease such as leukemia.

Chemical examination of the blood for sugar is indicated in diabetes. In oliguria the non-protein blood nitrogen should be determined if uremia is suspected. Attending the copious vomiting of high intestinal obstruction, dechlorination and dehydration with elevation of the non-protein blood nitrogen, decrease of the plasma chlorides and alkalosis occur (increased combining power of the blood for carbon dioxide). These alterations do not occur in the presence of adequate fluid administration which insures the satisfactory output of urine and corrects the above findings if they exist. The same findings occur rarely in low obstructions. The determination of these values in the blood is not essential for the recognition of bowel obstruction. In atypical cases, however, valuable information may be gained from them. If there be any question concerning the state of hydration of the patient, determination of the values for the non-protein blood nitrogen, the plasma chlorides and carbon dioxide combining power of the blood will help to decide the issue.

Röntgenography

The employment of the x-ray supplies evidence on two important considerations. In no other manner is reliable information to be obtained

of an enema. The duodenal tube has superseded the enema in the relief of intestinal distension.

E LABORATORY PROCEDURES

The Urine

A urine examination is to be made a matter of routine in every patient with an acute abdominal disorder. Its greatest worth resides in its value as a safe guard in detecting lesions of the urinary tract and particularly of the kidney which might in atypical instances be mistaken for appendicitis, salpingitis of the Fallopian tube, or other intraperitoneal disorder. Microscopic examination of the sediment of a centrifuged specimen will serve to identify instances of pyuria or hematuria occasioned by urinary infection or stone. In the febrile state of peritonitis, occasional white and red blood cells are observed commonly in the urinary sediment. Chemical examination of the urine for albumin and sugar will serve to recognize systemic diseases which may be present concomitantly as nephritis or diabetes. A faint cloud of albumin is present not uncommonly in febrile conditions. The finding of urinary sugar should suggest the necessity of ascertaining definitely whether the patient may have diabetes—a very important consideration in the administration of fluid as well as in the ultimate prognosis. In this connection it may well be recounted also that the acidosis of diabetes per se may simulate almost any acute abdominal disorder. An antecedent story of nausea, vomiting, and abdominal pain is elicited frequently and, on physical examination, the abdomen may be found rigid. The flushed cheeks, the acetone on the breath and the acetone bodies in the urine will identify readily the true state of affairs. In such cases a blood sugar determination should be made and the degree of acidosis ascertained by an assay of the combining power of the blood plasma for carbon dioxide.

In urinary tract disorders, more elaborate clinical chemical, and bacteriological tests are frequently necessary which lie outside the province of a chapter on general diagnosis of acute abdominal lesions. The writer has had no experience in evaluating the significance of indicanuria in bowel obstruction. It need not be looked upon as a diagnostic sign of any great value. The importance of determining the daily urine output in patients with acute lesions, whether treated conservatively or by operation, can not be over emphasized. A satisfactory twenty-four hour urinary excretion (700 to 1000 cubic centimeters) in which the presence of sodium chloride can be demonstrated is a good and practical test of an adequate fluid balance, and affords the best guide in the determination of how liberally para oral fluids should be administered. It is a good plan to have the nurses record the specific gravity of each voided specimen of urine. When the specific gravity exceeds 1.024 the administration of larger quantities of para oral fluids is indicated. It is to be remembered, however, that excretion of sodium chloride and glucose in the urine tend to keep the specific gravity of the urine high.

appearance of the film. If the distension be limited to the colon, he is likely to affirm the presence of mechanical obstruction of the colon, if the small intestine alone is distended and no evidence of separation of intestinal coils by fluid is suggested he is likely to diagnose mechanical obstruction of the small intestine, and if distension concerns both the large and small bowel and particularly if fluid separates intestinal coils he will probably make a diagnosis of ileus due to peritonitis (Fig 18). Now, to be sure, these are the typical roentgen findings of each of these afflictions. It is, however, decidedly unsafe to express an opinion from the roentgen evidence alone and this practice of roentgenologists should be discouraged. The appearance of thickening of the bowel wall on the x-ray film owing to the transudation of fluid into the peritoneal cavity, may occur in simple but more often in strangulating obstructions, as well as in peritonitis. The auscultatory phenomena elicited when correlated with the roentgen findings relating to intestinal distension afford a much more worthwhile opinion. And when the events of the history and the physical examination and the findings on gastric intubation are integrated into this judgment a trustworthy decision will in all likelihood be made.



FIG 19—X-ray film taken in the erect posture to demonstrate the presence of pneumoperitoneum. This finding indicates escape of gas from the gastro-intestinal tract.

When gas is observed in the free peritoneal cavity of the patient with an acute abdominal lesion the roentgenologist is almost invariably correct when he states that a leak has occurred in the gastro-intestinal canal (Fig 19). Apart from the occasional finding of a pneumoperitoneum of unexplained origin without symptoms the only condition which may give rise to confusion would be the production of gas in an intraperitoneal abscess by the activity of bacteria—a very rare occurrence in the experience of the writer. If the patient has a very rigid abdomen and suffered immediate and great disability from the onset and a film properly made fails to show gas below the diaphragm the clinician should not be deterred from making a diagnosis of perforated ulcer. In such an instance the site of perforation was probably quickly sealed off with a wisp of fat from the gastrocolic or gastrohepatic omentum. Instances of this nature have come to the writer's attention where the examiner guided by the clinical findings believed that perforation had actually occurred urged the roentgenologist to give the patient a few swallows of barium when no gas could be demonstrated beneath the diaphragm. Observing that the barium remained within the confines of the stomach and duodenum the examiner concluded that the ulcer was perforating in type only later to find that gas had now become visible beneath the diaphragm. When gas can not be demonstrated beneath the diaphragm, in the type of case just

concerning these two particulars, viz (1) the grade of intestinal distension and the location of the distended coils and (2) whether free gas is present in the peritoneal cavity. To be certain, it is not necessary in every acute abdominal condition to secure exact information on these points. It is when bowel obstruction is suspected that enlightenment is especially sought concerning the state of intestinal distension, in the distension accompanying paresis of the bowel attending many acute abdominal dis-

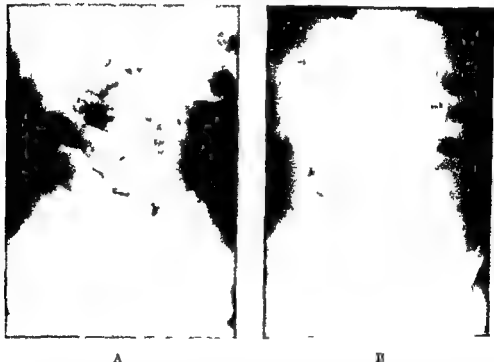


FIG 18—X ray films of the abdomen in peritonitis. It is apparent that more information is obtained from the film made in the supine position (a) than from that taken with the patient erect (b). In the latter, gas is mirrored over fluid. In (a) the grade of intestinal distension can be made out and the apparent thickening of the wall of a dilated bowel suggests that fluid is present between the coils. On auscultation the abdomen was silent. In all borderline conditions in which the possibility of perforation suggests itself the erect film should always be made.

orders as well as after abdominal operation, only a roentgen film can give dependable information concerning the degree and character of the distension. Aside from the instances in which perforation of the gastrointestinal canal is inferred from the history and the physical examination, the search for free gas in the peritoneal cavity is indicated in every borderline condition in which evidence suggests the presence of peritonitis, but an exact or satisfactory diagnosis can not be made.

It is to be emphasized concerning the interpretation of films, as it relates to the state of intestinal distension, that this information must be integrated into the clinical picture. Too often, a roentgenologist unfamiliar with the details of the history or physical examination essays to determine whether mechanical or inhibitive (paralytic) ileus is present on the sole

appearance of the film. If the distension be limited to the colon, he is likely to affirm the presence of mechanical obstruction of the colon, if the small intestine alone is distended and no evidence of separation of intestinal coils by fluid is suggested, he is likely to diagnose mechanical obstruction of the small intestine, and if distension concerns both the large and small bowel and particularly if fluid separates intestinal coils, he will probably make a diagnosis of ileus due to peritonitis (Fig. 18). Now, to be sure, these are the typical roentgen findings of each of these afflictions. It is however, decidedly unsafe to express an opinion from the roentgen evidence alone, and this practice of roentgenologists should be discouraged. The appearance of thickening of the bowel wall on the x-ray film owing to the transudation of fluid into the peritoneal cavity, may occur in simple but more often in strangulating obstruction as well as in peritonitis. The auscultatory phenomena elicited when correlated with the roentgen findings relating to intestinal distension afford a much more worthwhile opinion. And when the events of the history and the physical examination and the findings on gastric intubation are integrated into this judgment, a trustworthy decision will in all likelihood be made.



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When gas is observed in the free peritoneal cavity of the patient with an acute abdominal lesion the roentgenologist is almost invariably correct when he states that a leak has occurred in the gastro-intestinal canal (Fig. 19). Apart from the occasional finding of a pneumoperitoneum of unexplained origin without symptoms the only condition which may give rise to confusion would be the production of gas in an intraperitoneal abscess by the activity of bacteria—a very rare occurrence in the experience of the writer. If the patient has a very rigid abdomen and suffered immediate and great disability from the onset and a film properly made fails to show gas below the diaphragm the clinician should not be deterred from making a diagnosis of perforated ulcer. In such an instance the site of perforation was probably quickly sealed off with a wisp of fat from the gastrosolic or gastrohepatic omentum. Instances of this nature have come to the writer's attention where the examiner guided by the clinical findings believed that perforation had actually occurred, urged the roentgenologist to give the patient a few swallows of barium when no gas could be demonstrated beneath the diaphragm. Observing that the barium remained within the confines of the stomach and duodenum the examiner concluded that the ulcer was perforating in type only later to find that gas had now become visible beneath the diaphragm. When gas can not be demonstrated beneath the diaphragm, in the type of case just

referred to, the examiner must not discard and abandon the clinical evidence in favor of the negative roentgen findings. When the clinical evidence points to ulcer perforation, but air can not be demonstrated below the diaphragm, Beck injects air into the stomach through a duodenal tube and places the patient in the left lateral decubitus. Beck finds that, not uncommonly, air can now be demonstrated below the diaphragm on a roentgen film when the patient is returned to the erect position.

Unfortunately, in perforations of the bowel, gas can not be demonstrated so readily beneath the diaphragm as in ulcer perforation. Whereas 5 cubic centimeters of gas may be visualized not uncommonly (Paine and Rigler), it takes often as much as 20 cubic centimeters to separate liver and diaphragm. The stomach bubble on the left may give rise to confusion and should be removed by aspiration with a tube, in case of doubt. In the experience of this clinic, perforation of the appendix gives rise to a visible pneumoperitoneum, only very rarely.

He who has oriented himself concerning the value of the x rays with reference to the particulars described above finds it an indispensable aid. He must, of course, also be familiar with its shortcomings and limitations.

Now and then, one hears a voice raised to protest that only the old tried methods of the history and physical examination are of any value in the recognition of acute abdominal afflictions. He, who says to express such judgments, without access to the x rays in the elucidation of the two issues related above does not appreciate adequately what help he is denying himself.



FIG 20—Rupture of the retroperitoneal duodenum. Gas is shown around the right kidney and colon.

Method of Taking the Film.—To ascertain the degree of intestinal distension and the location of the distended coils, the film is best made with the patient lying supine, as will be described further in the next chapter. Determination of

whether free gas is present in the peritoneal cavity is to be made preferably with the patient standing or sitting upright. If he is too ill to assume these postures the film should be made in the left lateral decubitus with the presence of gas sought for on the film between the right border of the liver shadow and the abdominal wall. Rupture of the retro-peritoneal duodenum or colon may be recognized on the film taken with the patient lying supine and is disclosed by the appearance of gas external to the colon surrounding the kidney (Fig 20). The oral administration of barium to patients with acute intestinal obstruction is to be discouraged. Better evidence can be obtained sooner by careful examination of the scout film of the abdomen. Occasionally, it becomes

necessary to give a thin barium mixture by rectum to decide whether a distended intestinal coil concerns the large or small intestine. In acute great distensions of the colon suspected of being mechanical in origin, the writer has not found the barium enema as reliable, even in expert hands, in deciding whether a mechanical or functional obstruction is present, as is this same agent in the detection of a localized lesion of the colon, when distension is absent. If the distension of the colon is great and intestinal colic is present, even though the roentgenologist fails to disclose the presence of a lesion in the colon with a barium enema, decompressing the bowel by colostomy must be considered strongly. Two instances have come to the writer's attention in which so much reliance was felt in the roentgenologist's findings and opinion that the distension was ignored perforation of the cecum occurred and at necropsy a small but definite obstructing lesion was found in the pelvic colon. Viewing of the patient in the lateral positions beneath the fluoroscope and the taking of films in many positions serve to increase the likelihood of an obstructive lesion being visualized.

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obstruction is to decide whether *intestinal colic* is present. Intestinal obstruction of mechanical origin without *intestinal colic* does not exist. Having decided the presence of *intestinal colic*, it remains to be determined whether it be due to an actual block in the bowel to enterocolitis, food allergy or indiscretion. On the basis of such general symptoms as vomiting, distension, fever, and diarrhea this differential is made easily, usually.

Singularly enough obstructions at the pylorus which are observed clinically do not appear to give rise to a colicky type of distress nor do obstructions of the efferent loop at a gastrojejunal stoma. In other instances of mechanical intestinal obstruction observed by the writer whether the occlusion was found a few inches beyond the duodenojejunal angle or in the rectum intermittent colic or 'gas pains' were present, their origin in hyperactive intestinal contractions could be established definitely by the recurrent concurrence of audible borborygmi and colic.

The Vomiting of Bowel Obstruction

One of the characteristics of the vomiting of obstruction, as distinguished from other acute abdominal lesions is that it tends to be more frequent and abundant. The rationale of this occurrence is readily apparent in the existence of a mechanical block in the bowel, which brings about a regurgitation of the stagnant intestinal content into the higher reaches of the alimentary canal. When accumulation occurs in the stomach vomiting is copious usually.

There are observed clinically, not infrequently instances of mechanical obstruction in which the distension may be enormous and yet no vomiting occur. These are invariably found to be instances of obstruction of the colon. The explanation is more readily apparent in the character of the distension under which caption this feature will be discussed in some detail. Observation of clinical cases of obstruction has brought the conclusion upon the writer that feculent vomiting is uniformly an accompaniment of obstruction of the small intestine that *intestinal colic* attended by considerable distension without vomiting is usually due to obstruction of the colon. When a duodenal tube is passed into the stomach, in instances of obstruction of the colon no retention is found usually, and when fluid is recovered it exhibits the features of gastric or biliary content. Invariably however in obstruction of the small intestine of moderate grade unless vomiting has just occurred gastric retention is found to be present. The fluid recovered is frequently yellowish brown with the stercoraceous odor peculiar to the lower reaches of the small intestine.

It is apparent from what has been said previously concerning the ileocecal sphincter that it is responsible for these differences between obstructions of the small and large intestine. Under the caption of roentgen observations, this point will be elaborated further. The physical findings of obstruction will be described under the heading of How is the bowel obstructed?

General Physical Findings

On the whole very little help is afforded by the general condition of the patient in the recognition of bowel obstruction. His appearance usually

CHAPTER III

THE RECOGNITION OF OBSTRUCTION

THE significance of early diagnosis is attested in every reported series of obstruction where reference is made to mortality. It is stated frequently that, instances of bowel obstruction are difficult of recognition, especially because the physical findings are meager. It is the purpose of this discussion to indicate what the criteria are upon which a timely diagnosis may be made with some assurance. In particular, evidence will be presented upon which one may decide (1) whether obstruction is present, (2) what the location of the obstruction is, (3) whether the obstruction is complete or incomplete, and (4) the manner in which the bowel is obstructed.

IS THE BOWEL OBSTRUCTED?

The common complaints of patients with bowel obstruction are three (1) pain, (2) vomiting, and (3) distension. These complaints, it is true, are so much a part of all acute abdominal lesions that their occurrence affords no satisfactory distinguishing characters. The pain like that of other abdominal colics is crampy and intermittent, the vomiting is often frequent and copious and when the patient presents him self for examination, distension is present almost invariably.

Pain

The enhanced contractile activity of the gut in consequence of the presence of the intestinal block gives rise to intermittent crampy pain. The distress comes on suddenly, increases in crescendo fashion quickly reaching its maximum grade of severity which intensity is maintained usually for one to three minutes then the pain decreases and ceases as abruptly as it began. After free intervals of varying length the pain recurs again and again. Transudation of blood and fluid into the peritoneal cavity as occurs in strangulating obstructions, gives rise to a more continuous type of pain and gives rise to tenderness also.

The Significance of Intestinal Colic

Concomitant with these recurrent pains noises varying in quality with the character of the distension may be heard over the abdomen with a stethoscope at the acme of the pain. If the bowel is considerably distended by gas these sounds have a metallic character. Free admixture of gas and fluid in the distension is indicated by bubbling gurgling noises.

The synchronous concurrence of pain and noise (borborygmus) establishes the painful contraction as *intestinal colic*. Whereas *borborygmus* may be detected over the abdomen in other acute abdominal disorders there is no intimate time relationship as occurs when the cramp is of intestinal origin.

The first step therefore in determining the absence or presence of bowel

belies the presence of a potentially serious ailment. The respiration and blood pressure are normal usually. The pulse and temperature may be elevated slightly above the normal values. Apart from the pain of which the patient with obstruction complains, and the vomiting and the distension, he may not appear particularly ill. Late in obstruction, owing to dehydration and other changes in bodily economy not wholly understood, an anxious expression with sunken features, a feeble pulse, and cold and livid extremities may be observed.

In strangulating obstructions, especially if the segment be long whose blood supply is compromised, the pulse may be hurried, if the blood loss is great, the symptoms of shock are present usually. Owing to the irritation of the parietal peritoneum by the sanguineous fluid escaping into the peritoneal cavity, such a patient suffers more distress than the patient with simple obstruction.

Laboratory Aids

Similarly little specific help in the diagnosis of obstruction is obtained in general laboratory procedures. When vomiting has been a prominent feature, hemoconcentration occurs and increased values for hemoglobin, red cells, and leucocytes may be found. Demidova has observed concentration of all the elements of the blood in high intestinal obstructions and describes red cell counts of 6,000,000, hemoglobin values of 120 per cent and leucocyte counts as high as 30,000, with a tendency to appearance of immature forms. In low obstructions Demidova found changes from the normal less frequently. McKittrick and Sarris (1940) stress rightfully the importance of a rising leucocyte count as an indication of a strangulating obstruction. Yet, in their cases, the highest leucocyte count (38,000) was observed in a patient with simple obstruction. In this connection, it should be mentioned that Hill and Stoner (1941) observed leucopenia in dogs when intravenous injections were made from fluid recovered from the peritoneal cavities of other dogs with strangulated intestinal loops. When the fluid injected intravenously represented a transudate from obstructed loops (not strangulated), leucopenia was observed less frequently. The urine is usually scant and albumin or casts may be present. The kidney function is not impaired, for the liberal administration of saline solution corrects the oliguria and the abnormal urinary findings disappear.

Elevations in the non protein nitrogen of the blood decrease in the blood chlorides and an increase in the combining power of the blood for carbon dioxide occur only with regularity in clinical obstructions at the outlet of the stomach and the upper jejunum and then usually only after considerable fluid has been lost over a 48 hour interval. These changes are not observed in low obstructions, indicating that enough fluid must be absorbed from the gut to preclude serious loss of electrolytes. In consequence, these chemical alterations which may attend obstruction are not to be relied upon for diagnosis. In atypical instances they may be of some value.

A ray Observations—It is immediately apparent that the abdomen or the lungs for that matter, would be as dull on percussion as the liver

were it not for the presence of gas within these viscera. The distension of obstruction exhibits rarely any distinctive characters of which one can be certain clinically. With the aid of the radiographic film, however, one can procure reliable information as to the degree, extent, and location of distended segments of bowel.

Gas is normally present throughout the alimentary canal. Under normal conditions it is visualized on the roentgen film of the adult's abdomen only in the stomach and colon, the sites where food and intestinal content remain for some time. Whereas gas is present throughout the small intestine, the admixture between fluid and gas is so intimate because of the rapid rate of transit through the small bowel that gas is not visualized on the roentgen film. Under conditions of stasis in the small intestine, however, be the cause inhibitive (paralytic) or mechanical, gas and fluid separate out and gas is visualized. In the normal infant and child, however, gas apparently is visualized ordinarily in the small intestine until about three years of age. Following the establishment of experimental obstruction of the small intestine of the dog, it has been found that gaseous distension may be observed regularly on the roentgen film after four to five hours. Visible gas in distended loops of small intestine in the adult is, perforce, synonymous with intestinal stasis. The stethoscope serves to distinguish whether the stasis is of mechanical or inhibitive (paralytic) origin.

HOW IS THE OBSTRUCTION?

The roentgen film of the abdomen, interpreted in the light of the clinical findings, gives reliable information concerning the location of the obstruction.

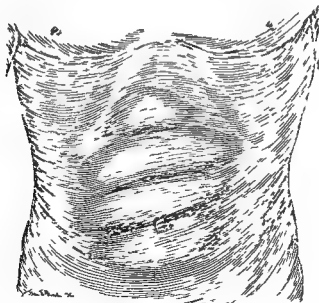


FIG. 21.—Visible and palpable coils of bowel in stricture of the small intestine.

belies the presence of a potentially serious ailment. The respiration and blood pressure are normal usually. The pulse and temperature may be elevated slightly above the normal values. Apart from the pain of which the patient with obstruction complains, and the vomiting and the distension, he may not appear particularly ill. Late in obstruction, owing to dehydration and other changes in bodily economy not wholly understood, an anxious expression with sunken features, a feeble pulse, and cold and livid extremities may be observed.

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X ray Observations—It is immediately apparent that the abdomen, or the lungs for that matter, would be as dull on percussion as the liver,

shadows in the obstructed small intestine may be described as a step-ladder arrangement of the coils, the mucosal folds of Kerkring within the bowel lend a feathery appearance. Acute angulations are described aptly as 'hair pin turns'. In the ileum, the valvulae conniventes are less prevalent than in the jejunum, in consequence, distended coils of ileum are more blank and somewhat characterless as contrasted with the feathery appearance of distended jejunal coils and the haustral markings of the distended colon.

Ordinarily, no difficulty exists in telling whether a given gaseous segment of distension concerns the small or large intestine. In atypical instances, however, it may be very difficult. In the main, the greatest difficulty lies in differentiating, with accuracy in borderline cases, whether the distension concerns the jejunum or the colon. Often, in such instances, the clinical signs fail to give a clear lead also. The feathery appearance of the distended jejunum may, in certain cases, be imitated so closely by a distended colon, as to preclude absolute differentiation. Because of its somewhat characterless appearance, distended ileum can be distinguished from the upper jejunum as well as a distended colon quite readily. If the choice of therapy is influenced by whether the distension concerns the jejunum or the colon, a barium enema should be given for purposes of ascertaining which viscus the areas of distension concern. When doubt remains and the situation demands detection of where the distension is, the administration of a thin mixture of barium as an enema will differentiate.

Almost as important as *intestinal colic* is in confirming the presence of bowel obstruction, is a proper appraisal of the distinguishing features between large and small bowel obstruction in determining which variety is present. This difference in behavior is predicated on the action of the ileocecal valve and sphincter as a check valve precluding regurgitation from the distended colon into the terminal ileum in obstruction of the colon, yet permitting the fluid excreted into the upper reaches of the intestinal canal and swallowed air to make their way, unimpeded apparently into the colon. In consequence there is frequently no gastric retention in obstruction of the colon and feculent vomiting is *always* absent and vomiting is frequently entirely absent. Now and then, reflex vomiting may be present initially. When the duodenal tube is passed and suction applied, only gas is re-aspirated usually and occasionally small amounts of fluid which can be identified as having its origin in the stomach or upper small intestine. Several instances of perforation of the cecum unassociated with vomiting occasioned by such rises of intraluminal pressure in colon obstructions as to cause necrosis of the bowel wall have come to the writer's attention. In one of these the occlusion was a small annular carcinoma at the beginning of the ascending colon not more than four centimeters above the point of entrance of the ileum into the colon. This is probably the only type of bowel obstruction which may not be accompanied by early distension (Fig. 22). The more usual location of the obstruction which gives rise to perforation of the cecum is in the more distal reaches of the colon and particularly the pelvic colon.

tion In the writer's experience, the distension of acute obstruction of the large bowel is limited usually to the colon Even at operation the terminal ileum is found not distended, as a rule It is not to be denied that occasionally the small intestine may participate in the distension of an obstructed colon—the reason being that one of the lips of the ileocecal valve is deficient

The ileocecal sphincter and valve operate in the manner of a check-valve, permitting gas and fluid from the small intestine to be swept into

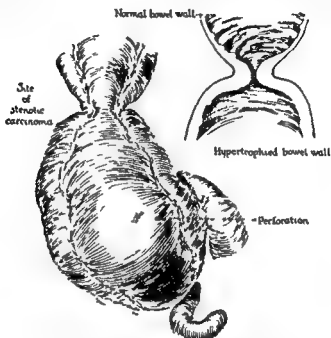


FIG 22—Tension perforation of cecum due to carcinoma
tous stricture of ascending colon The patient a physician had intermittent gas pains for six months There was no vomiting or distension prior to perforation

the colon, but having once entered, their re entry or regurgitation into the small intestine is prevented by the sphincteric mechanism The failure of the small intestine to participate in the distension accounts for the frequent absence of any vomiting in colonic obstructions

Determination of whether the distension observed on the film concerns the small bowel or colon is made readily usually Gas in the small intestine is characterized by its central location the long axis of the shadow is usually transverse and, when the loops are considerably dilated the two intestinal walls separating adjacent loops are seen as a very thin and narrow wall The occurrence of a fairly thick wall separating greatly distended loops suggests the presence of fluid or exudate between them Gas at the lateral borders of the abdomen is ordinarily in the colon the long axis is usually vertical and the intestinal walls are thicker and haustral markings are frequently in evidence The typical appearance of gaseous

Intestinal colic with distension limited to the colon indicates that the site of the obstruction is in the colon (Figures 12 and 23). The exact location of the obstruction in the small intestine cannot be determined with the same accuracy as in the colon. On the whole however, from the pattern of arrangement of intestinal coils described by Mall, one can readily tell whether the obstruction is in the upper, middle, or lower thirds of the small bowel.

How Should the Film Be Taken?

The film made with the patient lying supine gives the best information as to the pattern of arrangement of the distended intestinal coil. Even



FIG 24—Roentgenogram in acute obstruction due to carcinoma of the ileocecal valve and phinetar Obstruction at the ileocecal valve occludes the small intestine Mr M T aged 64 was admitted to hospital with a story of recurrent attacks of crampy abdominal pain and vomiting extending back over several months The present attack began about four days previously (a) The roentgenogram indicates the distension This film was taken in the usual manner with the patient lying upine (b) This radiograph was made with patient lying upon his abdomen The distended coils being nearer the plate the diameter here shown approaches more accurately the true distension It is apparent however that the continuity of the distended coils can not be determined as in A Following decompression accomplished by an indwelling duodenal tube the administration of a barium enema revealed a filling defect in the cecum A carcinoma was excised successfully (c) The reaction attending decompression and the quantity of fluid and gas aspirated are shown in the graph

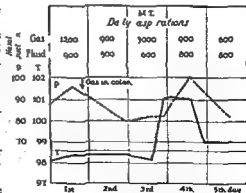




FIG 23—Obstruction of the colon (a) Film taken with patient lying supine. The opaque circular object is a five cent piece taped over the umbilicus. It lies on the anterior abdominal wall and is nearest the film and in consequence is enlarged considerably—its diameter on the original film was one-third greater than actual size. The bowel lying within the peritoneal cavity is further from the film and its diameter is magnified correspondingly less (usually about 25 per cent). (b) Film taken with the patient lying prone. The five cent piece and its shadow on the original diagram had identical diameters. The diameter of the distended colon shown here is more like that observed at operation. Lying on the abdomen has forced gas into the small intestine. The smooth outline of the mid-sectional group of coils definitely stamps them as being ileum. (See also Fig 12)

These occurrences attest well the usual competency of the ileocecal valve and sphincter in preventing retrograde flow into the small intestine. Yet, if the lower lip of the ileocecal valve should be deficient, the orifice would be patulous and regurgitation into the ileum could occur.

Distension is common to all varieties of bowel obstruction. In the more chronic types of occlusion, the fluid content of the obstructed bowel at operation is found to be considerably greater in amount usually than in the acute obstructions in which gaseous distension is ordinarily prominent. In the dog, accumulation of gas in a segment of gut just proximal to an artificially established obstruction in the small intestine may be detected on an x ray film after four to six hours. Usually, when patients come under observation, for obstruction, distension recognizable clinically is present.

Distension, nausea, and vomiting with feculent regurgitation accompanied by *intestinal colic* indicate the presence of obstruction of the small intestine. Distension, frequently of high grade, unattended by nausea or vomiting, with no return of colored intestinal fluid on gastric aspiration, but accompanied by *intestinal colic*, is synonymous with obstruction of the colon. The value of the roentgen examination lies in affirming these impressions and revealing the exact location of the distended segments of bowel.

measurement of the diameter of the distended intestinal coils gives information of real value. With employment of conservative means of decompression, it is particularly desirable to ascertain by measurement, whether the calibre of the distended intestine is being reduced by the exertion of suction.

A large film is placed beneath the patient, with the cone of the x-ray tube 30 inches from the plate. Almost invariably, the x-ray technician, unless instructed, will take the film too low—so low, that a good portion of the femur shows on the x-ray film. In most intestinal obstructions, that portion of the abdominal cavity, shown on the film below the great trochanter of the femur, exhibits rarely any useful information to aid in making the diagnosis of obstruction. The writer has made it a rule, therefore in the taking of scout films to determine the presence of distension, in suspected bowel obstruction that, the lower margin of the film come not lower than one centimeter below the anterior superior spine of the ilium. A film taken in this manner shows the diaphragms, the stomach, and the location of the indwelling duodenal tube, as well as the large area of the greater portion of the abdomen.

C IS THE OBSTRUCTION COMPLETE OR INCOMPLETE?

The grade of distension of the distended coils is a fair but not an absolute measure of whether the obstruction is complete. Inasmuch as the ileocecal sphincter and valve make of the colon a closed loop, complete obstruction of the large bowel is soon attended by alarming distension of the colon and particularly of the cecum, for it is the most distensible. Incomplete obstructions of the colon are attended by lesser grades of distension and gas is evacuated by rectum usually.

Whether obstruction is complete or not in the small intestine is to be determined by whether gas is observed to persist in the colon or on the roentgen film after a preliminary evacuant enema has been administered. This thesis is predicated on two facts: (1) The chief source of gas in the intestine is swallowed air. (2) The bowel distal to the obstruction is functionally as well as anatomically normal and its content may be removed with enemas. Considerable distension of the small intestine, without the presence of visible gas in the colon after preliminary evacuant enemas indicates that the obstruction is complete (Fig 26), distension of the small intestine accompanied by persistence of gas in the colon identifies an incomplete bowel obstruction, when distension of the small intestine is accompanied by persistence of gas in the colon, an incomplete obstruction is suggested by these findings (Fig 27).

D HOW IS THE GUT OBSTRUCTED?

The gut may become obstructed in a number of diverse manners. From the anatomic standpoint, however, there are but two types of obstruction with variants in degree, viz: (1) simple obstruction presenting interference to the continuity of the bowel alone. (2) strangulating obstruction which exhibits in addition to a block in the bowel, compromise of the blood supply.

The abdominal physical findings of the two anatomic varieties of ob-

though the distended loops appear somewhat larger than they really are, it is the only exposure in which the distended coils can be traced through in continuity. When the film is made with the patient lying prone, a truer diameter of the intestinal coils is obtained, the bowel being near the plate. Owing to the pressure upon the intestine with the patient lying on the abdomen however, the continuity of distension cannot be followed through. It is also apparent that enough gas must be present in the distended bowel to afford adequate contrast, if the distension were wholly or largely fluid (a rare occurrence), the actual degree of intestinal distension may not be apparent in many coils.

A film made in the erect or lateral posture permits of visualizing "gaseous mirrors" over fluid levels in the bowel. No reliable information can be obtained from such a film as to the exact location or the actual degree of intestinal distension present. Under ordinary circumstances, therefore, a single large film of the abdomen (scout), taken with the patient lying supine is the most valuable in that it gives the most desired information. In chronic obstructions in the presence of considerable fluid in the bowel, an erect film is more likely to detect the presence of gas, mirrored over the fluid, than is the film taken with the patient supine.

A number of measurements made of distended intestinal coils at operation and compared with the diameter of the distended coils on the x ray film suggests that the antero-posterior film, made with the patient lying supine, occasions an enlargement of the true intestinal diameter of about 25 per cent. A five cent piece fastened over the umbilicus with adhesive tape lies nearer the source of the x rays, and owing to the greater diffraction of the rays, exhibits an enlargement of 33 per cent, in the patient with an abdominal wall of ordinary thickness (See Fig 23). With these factors in mind the clinician may obtain reasonably accurate information from the x ray film, concerning the true diameter of the distended intestinal coils. It is obvious that in the case with simple obstruction, at least, the



FIG 25.—On first glance this film would suggest a mechanical obstruction of the small intestine. The outer wall of jejunal coils however can be seen—a finding which indicates that air must be present in the peritoneal cavity. An erect film verified this suspicion. The initial story had been one of intestinal colic without vomiting. On the basis of the history and this roentgen film a diagnosis was made of carcinoma of the colon with perforation of the cecum (permitting decomposition of the distended colon into the peritoneal cavity). At operation an annular carcinoma was found at the hepatic flexure and the perforation in the cecum was closed. From the history one would infer that the perforation had been present about 5 hours. The patient of course did not survive peritoneal soiling in the presence of obstruction is almost invariably fatal.

struction are sufficiently distinctive usually to permit of differentiation. The patient with a simple block in the bowel exhibits no tenderness or rigidity of the abdominal wall unless the gut is so distended that its wall weeps. If, however, the return flow of blood through the mesenteric veins is interfered with the gut becomes infarcted and a sero sanguineous fluid escapes into the peritoneum causing the latter to become sensitive. If a considerable segment of bowel becomes infarcted, a tender mass may be made out over the abdomen or by digital examination of the rectum or vagina. Intussusception is the single variety of strangulating obstruction in which the abdominal wall may be found to be relaxed and not tender. The explanation is quickly apparent in that the infarcted intussusceptum is within the normal ensheathing layer. When bloody fluid escapes into the peritoneal cavity as happens occasionally tenderness is present. The other findings such as mass and evacuation of blood and mucus by stool are sufficiently distinctive to serve to identify its presence. During the colic the abdominal wall may stiffen and relax in the free interval. Similarly, in simple obstruction a tightening of the abdominal wall may be made out when the patient is suffering pain. The same effect may be observed with an inflated balloon or upon faradic stimulation with an electrode within the gut.

Intestinal colic without tenderness of the abdomen signifies the presence of a simple obstruction.

Intestinal colic accompanied by abdominal tenderness suggests that a strangulating obstruction is present. The grade of rigidity of the abdominal muscles is usually not great for blood is not as severe an

irritant of the parietal peritoneum as is hydrochloric acid (0.5 per cent) which, when pilled into the abdomen following spontaneous perforation of an ulcer, gives rise to a board like abdomen. Purulent affections of the peritoneum also give rise to a greater grade of rigidity than that attending the escape of blood into the peritoneal cavity. Occasionally, in simple obstruction because of increased intraluminal tension, the gut may weep and fluid will be transuded into the peritoneal cavity, giving rise to tenderness suggesting necessity for operative intervention.

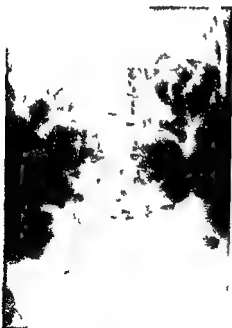
McKittrick and Sarris (1940) are not willing to allow that abdominal



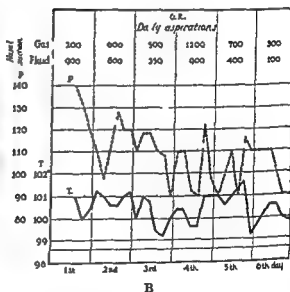
FIG 23—The plain ray in chronic obstruction of the small intestine. Films made two hours after the oral administration of barium in a patient with chronic intestinal obstruction. Ten years previously this patient had suffered with tuberculous peritonitis. Barium is not to be given in acute obstructions.



FIG 26—Complete obstruction of the small intestine Mrs F H aged 29 (Table 10 p 138 Case 1) Radiograph of abdomen on entry to hospital after 24 hours of abdominal pain and vomiting. Intestinal noises with a metallic character were heard with the stethoscope at the height of the recurrent pains establishing the presence of intestinal colic. Numerous enemata had been administered prior to admission and no gas was visualized in the colon indicating that the obstruction was complete. There were no signs of peritoneal irritation. The patient convalesced satisfactorily after enterostomy. The fluid drainage is indicated in Table 13. The relatively small escape indicates that the continuity of the bowel was restored quickly.



A



B

FIG 27—Incomplete obstruction of the small intestine (a) Radiograph of abdomen of Miss G R aged 20. Crampy abdominal pain and profuse vomiting of 24 hours duration. There was no abdominal tenderness. Appendectomy was done for suppurative appendicitis three months previously. There is moderate distention of several coils of small intestine. Gas is also present in the colon after evacuant enemata have been given indicating that the obstruction is incomplete. (b) The patient was satisfactorily decompressed by suction applied to an oblique duodenal tube. The quantities of fluid and gas aspirated and the length of time over which suction was exerted are indicated in the accompanying graph as are also the pulse and temperature reactions attending the employment of suction. There has been no recurrence of symptoms of bowel obstruction in the intervening seven years.

delay in transit of barium through the small intestine as determined by the 'stasis ray'. The patient may take a full diet containing a good deal of cellulose, which ordinarily leaves considerable residue, without ill effect. Suddenly acute obstruction supervenes with pain and vomiting and the 'washboard' abdomen with elevations and depressions occasioned by the hypertrophied gut is readily made out. Such an attack may then subside to be followed by comparatively long intervals without symptoms (See p 82)

F IDENTIFICATION OF THE TYPE OF OBSTRUCTION

The exact nature of the obstructing agent and the precise manner in which it obstructs the gut are items upon which information at best is inferential and not absolute. External hernias, the congenital obstructions such as intestinal atresia and imperforation of the rectum and anal canal, intussusceptions of infancy, and mechanical obstructions of the left colon may be identified with accuracy usually by the rather obvious findings or characteristic train of symptoms present. Occasionally, functional spastic obstructions with considerable distension of the colon may be confused with obstruction of the pelvic colon due to carcinoma or diverticulitis, but the aid of the barium enema serves to differentiate usually. The greatest difficulty is in accurate recognition of the exact nature of an obstruction in the small intestine. When strangulated external hernia and invagination of the bowel which are statistically rather common varieties of obstruction are excluded adhesive obstruction is by all odds the most likely. It is probably the most frequently observed of all varieties of obstruction and concerns almost invariably the small intestine alone. Yet, obstruction of the small bowel by a gallstone, carcinoma of the small intestine or an enteric intussusception though uncommon occur sufficiently frequently to demand attention in the consideration of the probable nature of a small bowel obstruction and even obstruction of the intestine by a band may be difficult to identify without operation. *volvulus of small*

In the experience of the writer one of the most difficult differential diagnoses is to distinguish between a strangulating type of obstruction presenting *intestinal colic* and rebound tenderness and atypical acute inflammatory lesions which in turn may be complicated by simple obstruction. The history, the degree of tenderness present, and the distribution of gas in the gut aid materially often in differentiating. In those inflammatory lesions however in which the obstructing element is such that a fairly complete obstruction exists, it may be impossible to differentiate.

G ESTABLISHING THE DIAGNOSIS

There usually is no difficulty in ascertaining that the gut is obstructed. In any acute abdominal disorder presence or absence of obstruction is determined readily usually by the presence or absence of *intestinal colic*. At the same time, one can with the aid of a radiographic film as has been indicated determine whether the obstruction concerns the colon or the small intestine. The absence or presence of vomiting as well as the occurrence and grade of gastric retention as determined by aspiration afford a valuable clue. The grade of intestinal distension and whether the obstruction is

tenderness will serve to distinguish simple and strangulating obstructions. Yet, of all the differential characters, it is unquestionably the most reliable. At the same time, it is to be admitted freely that tenderness of the abdominal wall may be observed during the course of simple obstruction. It is wise to regard all obstructions, exhibiting definite evidences of abdominal tenderness, as instances of potential strangulation. This matter will be discussed at greater length subsequently.

Hill O'Loughlin and Stoner (1942) have suggested recently aspiration of the peritoneal cavity with a fine needle, in suspected instances of strangulating obstruction. In dogs, they were able to recover blood from the peritoneal cavity regularly when 4 hours had elapsed after establishment of intestinal strangulation. Van Duyn (1942) believes that distension per se may cause leucopenia.

INTEGRATION OF THE TIME ELEMENT INTO OBSTRUCTION

The rapidity with which an obstruction develops is reflected in the clinical manifestations. On the whole, however, the element of time is not

so important as the degree of completeness in determining the sequence of events. Patients presenting visible and palpable peristaltic contractions through an abdominal wall of normal thickness uniformly have an obstruction of some standing. Acute obstruction not infrequently supervenes and accentuates the symptoms. The essential difference between a bowel that has been partially obstructed for some considerable time and an acute obstruction is that in the instance of the former, the circular muscle of the bowel has had time to hypertrophy and the gut wall may be markedly thickened, in acute obstructions of high grade, the gut wall is always thin, and palpable or visible peristalsis are rarely seen.

Strictures in the bowel are the usual cause of chronic obstruction. Their most usual site is the pelvic colon, and their most usual cause is an

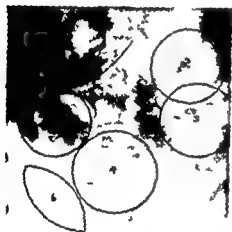


FIG. 29.—The anatomic situation of the loops of small intestine as described by Mall. The loops show up in the designated numerical sequence on roentgen study (More and Naslund, *Surgery* 1: 886, 1937).

annular carcinoma. The mild recurrent grumbling gas pains and increasing constipation, together with the contour of the palpable contractions, are tell tale signs of its location. In the small bowel, the symptoms are dependent in large measure on the location of the stricture. A stenosis in the upper jejunum will give rise to symptoms more readily than a similar stenosis in the lower ileum, where the normal contents of the bowel are quite fluid in character. It is surprising how a high grade stenosis of the lower small intestine may be tolerated for long intervals without any demonstrable subjective or objective phenomena. There may be no detectable

Strangulating Obstructions

These are characterized by the presence of a block in the bowel with the added factor of infarction of the imprisoned segment of bowel. When the interference with venous return is great, the irritation of the parietal peritoneum brought about by the escape of sanguineous fluid into the peritoneal cavity may dominate the picture. In lesser grades of venous block the symptoms of peritoneal excitation may come on tardily.

A large number of conditions must necessarily be thought of in the differential diagnosis of strangulating obstructions including all the abdominal colics, such as biliary and renal seizure, the inflammatory conditions such as appendicitis, salpingitis and peritonitis, pancreatic necrosis and diaphragmatic pleurisy, purpura, hemophilia and other lesions with intestinal occlusion due to hemorrhage into the bowel wall and mesentery, as well as the torsion of other organs especially ovarian cysts and the testes.

Torsion of the testis concerns usually one which is imperfectly descended. Absence of the testis from the scrotum, together with a tender mass in the groin or lower abdomen which may exhibit bluish discoloration serves to identify the condition. Apart from the absence of *intestinal colic*, an ovarian cyst twisted on its pedicle may imitate closely the clinical features of small bowel obstruction. Reflex vomiting in the beginning may be prominent; later vomiting is usually absent. Shoulder pain from the escape of blood into the peritoneal cavity is common. Fever, leucocytosis, and a quickened pulse are frequent findings. The tenderness is usually confined largely to the lower abdomen. The cyst may or may not be palpated. Recognition of its presence is ordinarily not difficult. The stethoscope serves to differentiate the condition from a strangulating obstruction. Yet fibrinous adhesions about such a strangulated cyst may give rise to concomitant simple mechanical obstruction of the bowel.

The difficulty of distinguishing between a strangulating type of obstruction presenting *intestinal colic* and rebound tenderness and an inflammatory lesion which in turn may occasion some interference with the continuity of the gut was alluded to above. In the inflammatory lesions in which the obstructing element is conspicuous it may be impossible to distinguish whether a strangulating obstruction alone exists or whether an inflammatory lesion complicated by a simple obstruction is present. Now this differentiation is not alone a matter of academic interest; moreover it is one of vital concern for the patient. It has been the observation of the writer when the abdomen is opened in peritonitis where exudate is obstructing the gut that frequently the infection which the patient has been satisfactorily controlling is spread by the operative interference; the barriers of resistance are broken down and the patient dies. It is the writer's earnest conviction borne out by the demonstrated wisdom of conservative management in similar cases that where a strangulating obstruction can be excluded adequately a nonoperative course assumes much less risk for the patient—the distension being dealt with by suction applied to an indwelling duodenal tube.

complete or incomplete can be decided by a roentgen film when preceded by the administration of an evacuant enema. It may be impossible, however, to distinguish clearly just the nature of the obstruction without recourse to operation. Whether it is simple or strangulating in character may be determined with precision usually by the physical findings.

II THE DIFFERENTIAL DIAGNOSIS OF OBSTRUCTION

Briefly it may be stated that cases of simple obstruction are simulated most closely by colics that are unattended by local abdominal physical findings. Strangulating obstructions must be differentiated from every colic that produces tenderness and rigidity of the abdominal wall. In both varieties the distinctive finding of *intestinal colic* serves to establish the fact that obstruction is present. No other acute lesions of the abdominal viscera are attended by such a pathognomonic finding.

Simple Obstruction

The number of conditions which may be confused with simple acute obstruction are not many, for the most acute abdominal afflictions are ac-

companied by abdominal tenderness. The very occurrence of colicky abdominal pain without tenderness should therefore suggest the possibility of simple obstruction. The lesion that early simple intestinal obstruction may be mistaken for is the simple "belly ache" under which category one might list food indiscretions of one sort or another, intestinal allergic reactions and acute enterocolitis. In these usually, diarrhea is a prominent symptom and vomiting is missing altogether or a minor complaint. In enterocolitis, distension as visualized by roentgen examination, involves ordinarily both the large and small bowel. Whereas, in mechanical obstructions whether of the colon or small intestine, distension is limited to the bowel concerned. In obstructions of the small intestine, the colon is not distended even though in partial obstructions, gas persists in the colon after evacuant enemata have been given in acute obstructions of the colon



FIG. 30.—Roentgen films of air inflated segment of intestine. A Jejunum slightly distended exhibiting mucosal folds. B A jejunal segment somewhat more distended. C The characteristic ileum. D The colon with haustral markings. Distinguishing between distended loop of jejunum and colon is most troublesome source of difficulty.

distension of the small intestine is absent as a rule. Clinical distension is slight often in early cases of obstruction. The value of repeated examinations at short intervals is not to be forgotten in borderline cases.

Strangulating Obstructions

These are characterized by the presence of a block in the bowel with the added factor of infarction of the imprisoned segment of bowel. When the interference with venous return is great, the irritation of the parietal peritoneum brought about by the escape of sanguineous fluid into the peritoneal cavity may dominate the picture, in lesser grades of venous block, the symptoms of peritoneal excitation may come on tardily.

A large number of conditions must necessarily be thought of in the differential diagnosis of strangulating obstructions including all the abdominal colics, such as biliary and renal seizures, the inflammatory conditions such as appendicitis, salpingitis, and peritonitis, pancreatic necrosis and diaphragmatic pleurisy, purpura, hemophilia and other lesions with intestinal occlusion due to hemorrhage into the bowel wall and mesentery, as well as the torsion of other organs, especially ovarian cysts and the testes.

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Instances of acute pancreatic necrosis are not infrequently referred to hospital under the diagnosis of bowel obstruction. Here too, ascertaining whether *intestinal colic* is absent or present is exceedingly helpful. Borborygmi are not uncommonly heard but there are no associated "gas pains." Distension of the transverse colon, together with loops of small intestine, are the usual roentgen findings. An erect film helps to exclude perforation of an ulcer. In contrast to appendicitis, salpingitis, and torsion of an ovarian cyst—in which conditions the findings are largely in the lower abdomen, tenderness and rigidity in pancreatic necrosis are much greater above the umbilicus than below. The rigidity as differentiated from acute biliary tract disease is about equal, below both costal margins. An acute lesion of the abdomen accompanied by severe pain and prostration but without shock, not attended by *intestinal colic*, and in which the findings are largely in the upper abdomen and about the same to the right of the midline as on the left, in which no free gas is demonstrated on an x-ray film taken in the erect posture, is probably pancreatic necrosis. The writer failed to recognize the true nature of this disorder in the first patient, who came under his observation, for the findings were so different from the usual textbook descriptions of the disorder. Most cases of pancreatic necrosis that have been observed since, which have come to operation, have been correctly identified preoperatively by the criteria described above.

Instances of perforated ulcer are to be recognized in the great rigidity of the abdominal wall and by the presence of free gas in the peritoneal cavity, observed on an x-ray film made in the erect posture. So called "sealed perforations" may occur without free gas being visualized below the diaphragm. The extreme rigidity of the abdomen and the great and immediate incapacity of the patient serve to identify the disorder.

Typical instances of biliary or renal colic, salpingitis, ectopic pregnancy, and appendicitis, are usually easily identified. *Intestinal colic* is absent in all of them. In any atypical acute abdominal affliction the two roentgen observations of the abdomen described in the previous chapter, viz., the scout film and the erect plate aid materially in orienting the examiner concerning the probable pathological nature of the lesion.

Distinguishing Simple and Strangulating Obstructions

The absence or presence of signs of irritability of the parietal peritoneum suffice usually to differentiate these two varieties of obstruction. It is to be remembered, however, that an intussusception may be unattended by rebound tenderness because the infarcted intestinal segment lies within a normal ensheathing cylinder; hence, bloody fluid may not escape into the peritoneal cavity. Some simple obstructions of the colon virtually become strangulating in character because of the great increase in intraluminal pressure, the ileocecal valve and sphincter making of the colon a closed intestinal loop. In instances where the distension is great, tenderness over the cecum is frequently present and portends ulceration and necrosis of the bowel wall. Similarly, in an obstruction due to incarceration of a gallstone in the ileum, tenderness may come about through the agency of pressure erosion of the bowel wall overlying the stone.

In obstruction due to the attachment of an adhesive band to the anterior abdominal wall, point tenderness at that site is usual. The development and extension of abdominal tenderness in a patient whose findings were essentially those of simple obstruction constitute a warning that the features of strangulation have supervened. The suggestion of a mass which may be felt through the abdominal wall or made out by rectal or vaginal examination lends strong confirmation to this suspicion. These occurrences always suggest the necessity for immediate operative intervention.

Employing the criteria of differentiation here described, the writer has not found himself treating a patient with strangulated bowel expectantly. Yet, this accident has occurred a few times in this clinic. The difficulty lies usually, in over extending the indications for conservative management of bowel obstruction. It is to be remembered also that late in the course of a strangulating obstruction, the *intestinal colic* feature, so pathognomonic of obstruction may be absent altogether, owing to the inhibiting effect of increased intestinal capillary permeability upon intestinal contraction. Only by sitting at the patient's bedside patiently, and auscultating over long intervals at a time, will the presence of a mechanical obstruction be detected. All other evidence may point to intestinal distension, occasioned by causes other than a block to intestinal continuity. The need for repeated observations and an occasional resurvey of the situation is apparent. The writer, however, owns to having operated with the guidance of the old standards in a few instances in the fear that a strangulating obstruction was developing without actually finding it—an occurrence which, in the absence of peritoneal infection, he has had no occasion to regret. The usual finding in such cases of simple obstruction has been that the bowel was 'wet' because of the increased intraluminal pressure giving rise to exudation of clear straw colored fluid into the peritoneal cavity.

STRANGULATING OBSTRUCTION WITH LITTLE OR NO EVIDENCE OF DISTENSION

Without knowledge or experience of the occurrence of a strangulating obstruction, in the absence of distension, one may be persuaded to doubt the possibility of such a happening. And to be certain ordinarily the agency which brings about ensnarement of a loop of bowel or its torsion provokes a mechanical simple obstruction in the intestine immediately proximal to the strangulation. In the usual strangulating obstruction therefore, there are usually two coexisting varieties of obstruction, viz., (1) strangulation of the torsioned loop and (2) simple obstruction in the intestine proximal to the site of strangulation. It would seem sane to rationalize then that in order to initiate the strangulating effects of a compromised blood supply in the imprisoned loop, the strangulating mechanism should obstruct the proximal bowel. In the main as has been admitted such is the usual circumstance. Nevertheless as anyone who has had a wide experience with the bowel obstruction problem will bear witness occasionally a patient will present himself with a strangulating obstruction and a devitalized bowel demanding excision with little or no manifest evidence of distension. There may be little or no evidence of gaseous distension on the x ray film. As in most mechanical obstructions

vomiting is a predominant symptom. The abdomen is usually tender and a mass can be made out occasionally.

The lesson to be learned from all this is that the return of venous blood from an imprisoned loop of bowel may be impeded without the presence of a mechanical block to the continuity of the intestine. This occurrence is explicable only on the basis that (1) the agency responsible for the compromise of blood flow to and from the bowel does not occlude the lumen of the bowel and (2) transport is possible through a strangulated loop of bowel, which, at operation may give every evidence of having lost its viability. In mesenteric thrombosis, as will be pointed out subsequently (p. 453), distension and the manifest evidences of obstruction are frequently not prominent.

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PART III

GENERAL THERAPEUTIC CONSIDERATIONS IN THE MANAGEMENT OF BOWEL OBSTRUCTIONS

CHAPTER IV

GUIDING PRINCIPLES IN THE TREATMENT OF ACUTE ABDOMINAL LESIONS

A ABDOMINAL INJURIES

WORLD WAR Number II has focused attention again upon the importance of abdominal injuries. In the infantry type of warfare of previous wars, the incidence of injury of the abdominal viscera as contrasted with the more frequent injuries of extremities and head was not great. The mortality, however, has always been very high.

The abdomen is the largest cavity of the body and contains the organs dealing with alimentation and excretion, the adrenal glands which furnish the drive for our daily tasks and, in the female the genital organs. These abdominal viscera may be injured in a large number of ways. There are essentially two types of injury—wounds sustained as the result of blunt force and penetrating wounds such as bullet and stab, or wounds made by any puncturing type of instrument. The two most common consequences of abdominal injury are (1) Hemorrhage due to tears in solid viscera and (2) perforation of a hollow viscus. The intestines occupy a large portion of the abdominal cavity, so it is not surprising that intestinal injuries of one sort or another represent a large percentage of injuries to the abdomen. In injuries of the upper abdomen, the spleen is not infrequently injured. Injury of the kidney is one of the *most common sequences* of blunt trauma to the abdomen. Injuries of the bladder are also rather frequent. About half of them are associated with fractures of the pelvis and the other half attend injuries of the lower abdominal wall. The contents of the abdomen are protected in some measure by the abdominal muscles which overlay and envelop them. Injuries of the abdominal viscera are obviously much more common in men than in women, due largely to occupational hazards. Granted, however, the same trauma in women with lesser abdominal musculature frequently weakened by childbearing the same force will usually produce more serious damage.

When violence strikes the abdomen, it is usually the viscus which is immediately beneath the site of the blow which is injured. The state of digestion with reference to whether the stomach and intestine are empty or full is an important determinant in the occurrence of injury to the gastro intestinal canal. A distended intestine whose wall is thin, is much more likely to be damaged than an empty contracted bowel. When the bowel is fixed as at the duodeno jejunal angle and the terminal ileum, it is most susceptible of injury. It is surprising how easily the gut may be

ruptured by blunt force in such areas. A rather heavy woman seen in this clinic was raking her yard, stepped in a hole, lost her balance, fell on her back and ruptured the terminal ileum. Occasionally, however, the viscera lying directly beneath the point of trauma escape injury and the force of the blow is carried over to some other portion of the abdomen and expends itself upon a viscus less able to withstand the compression and disrupting effects of trauma. The liver is commonly injured by a crushing blow received in the upper abdomen. When the capsule of the liver is broken, the hepatic tissue offers slight resistance to fracture. Fractures of the right lobe of the liver are about eight times more frequent than injury of the smaller left lobe. Rupture of the gall bladder or common bile duct are uncommon injuries. The spleen being a vascular organ fractures readily when important vessels are torn the blood loss may be severe. Delayed hemorrhage attending splenic injury may sometimes come on a week or even a month later, and frequently presents a complication more dangerous than the original injury. Isolated injury of the mesenteric or omental vessels may occur or may accompany any of the injuries already mentioned. Isolated injury of the pancreas is quite unusual and occurs usually from severe blows in the epigastrium, as from the kick of a horse.

Any of the large blood vessels traversing the abdomen such as the aorta, the inferior vena cava or the iliac vessels, as well as the vessels which supply the abdominal viscera, may be injured in either blunt or penetrating types of trauma.

What Viscera Are Injured?

The scope of this presentation does not warrant going into any detail concerning the identification of the particular type of injury present. The general considerations discussed previously in the chapter on diagnosis of acute abdominal disorders, when integrated in the light of where the trauma was inflicted upon the abdomen, the nature of the trauma, the functional disturbance, the physical findings and the two x-ray observations mentioned viz a "scout" film and one in the erect posture, serve to afford quite satisfactory orientation concerning the probable pathological nature of the injury.

In the experience of the writer, liver injury has not been associated with bradycardia as described by Finsterer. Tenderness and normal dullness or percussion over the usual course of the ascending colon in injuries of the liver and over the descending colon in splenic injury are usual. Frequently an intraperitoneal hematoma may be palpated or identified by percussion. Kidney injuries may be identified by the presence of blood in the urine and if the local bleeding is great, by the palpation of a mass which may be felt both by a palpating hand in the loin as well as beneath the anterior abdominal wall. Bladder injuries are to be recognized in the difficulty of passing urine, the appearance of blood in the urine or failure to recover fluid injected into the bladder. Intravenous urograms may be of value, as may be the injection of an opaque medium (silver iodide) into the bladder in the recognition of kidney and bladder injury. It is to be remembered that, following the passage of a catheter

into the bladder when intraperitoneal rupture is present, air may make its way into the peritoneal cavity and be visualized beneath the diaphragm on the film in the erect posture. Perforation of stomach and intestinal canal are to be recognized in the presence of *free gas* below the diaphragm. Perforation of the small intestine is not accompanied by the escape of enough gas early, as a rule, to permit recognition of a gas bubble beneath the diaphragm. Gas is usually present in sufficient quantity in both the stomach and colon to cause it to accumulate beneath the diaphragm in sufficient amount to be recognized when a complete tear or perforation of the wall of the stomach or colon is present. Gas can not be visualized usually in the small intestine normally, and unless the bowel is distended, it may take some considerable period of time for sufficient gas to escape following perforation of the small intestine, to cause a collection large enough to be seen beneath the diaphragm.

The Treatment of Abdominal Injuries

Penetrating injuries The important matter to decide is whether operation is in order or whether the patient may be treated conservatively. In perforating injuries whether by a bullet, stab or other perforating object, operative intervention is almost invariably to be done as quickly and conveniently can be done for in the majority of instances a segment of the numerous twists and loops of the gastro intestinal canal is likely to be perforated, and as is apparent the time factor is very significant in determining the outcome. The sooner the perforation is closed by suture the better. As long ago as 1884 Parkes showed by shooting into the peritoneal cavities of dogs that spillage occurred almost invariably directly upon the infliction of the wound and perforation of the small intestine was usually present.

Perforation of the stomach is least hazardous, and especially when the stomach is empty. Bergh, Bowers and Wangenstein (1937) found that the stomach of the dog, cat and other laboratory animals could be perforated, and without closure of the perforation recovery would occur in about 85 per cent of instances if the stomach were empty at the time of perforation. If on the contrary food was present in the stomach at the time of perforation, the mortality without closure of the perforation was 88 per cent. The state of alimentation does not affect the outcome so significantly in intestinal injuries. Because of the acidity of the gastric juice, tears of the stomach afford a much more hopeful outlook than do similar injuries in the intestine. Whereas, one might reasonably expect the greatest hazard from ruptures of the colon the greatest risk is run apparently by patients who have perforations in the terminal reaches of the ileum.

When George Makins returned from the Boer war in 1901 he wrote a monograph advising the conservative treatment of perforating wounds of the abdomen. It is to be recalled however that a type of itinerant warfare was pursued there which did not permit of the establishment of bases at which emergency operations could be done well. Similarly, Nicholas Senn, in writing of his experience in the siege of Santiago in the Spanish American War, came to a conclusion similar to Makins'. Be it

ever said, therefore, to the great credit of American surgery, that when President McKinley was shot through the upper abdomen at Buffalo at the Pan-American Exposition in September, 1901, the surgeons in charge operated immediately and closed the perforation in the anterior and posterior walls of the stomach. The outcome was unfortunate, but even to day a similar outcome might have followed the extensive damage done by the bullet in the retroperitoneal space. Recent reports attest the hazard of such penetrating injury in the retroperitoneal tissue. Following the shooting of President Garfield in 1881, Marion Sims was prompted to write a dissertation upon bullet wounds of the abdomen, in which he advocated early operative intervention. In his prediction that, with early operative closure, intestinal perforation would no longer be very hazardous, he did not reckon adequately with the bacterial content of the bowel. Cushing and Livingood and Kendall in epoch making papers, have pointed out the dangers of peritoneal contamination with intestinal content. Until we come upon some pharmacological or immunological means of dealing adequately with the menace of escape of intestinal content, the mortality will probably continue to be lamentably high. Not enough information is available to indicate yet whether the local implantation of sulfathiazole to be described subsequently, will affect the issue materially. Even as late as the beginning of World War I, we find well recognized surgeons on both sides engaged in the conflict, advocating conservative treatment of perforating gun shot wounds of the abdomen. Let any one who still doubts the validity of operation read the illuminating report by Enderlen and Sauerbruch in which the superiority of the immediate operative attack is unequivocally shown. Closure of perforations, on the whole when feasible, is a better plan than intestinal resection.

Blunt trauma. When dealing with injuries in which the gastro intestinal canal is not perforated the need for operation is not so urgent. To be certain, a torn bladder should be sutured as quickly as possible. Experience has demonstrated however, that a damaged kidney may be managed conservatively with greater safety to the patient than by operation unless the bleeding is so severe as to demand operative intervention, in which event the risk also is great. This experience with the treatment of renal injuries suggested a trial of the same means in dealing with tears of the liver and the spleen. Over a period of more than 10 years, suspected injuries of liver or spleen, unless bleeding has been progressive have been treated conservatively in this clinic. In subcutaneous injuries by blunt force, the great risk in conservative management is rupture of the intestine. In fracture of the liver or spleen we operate rarely and almost invariably treat the patient expectantly, keeping close watch on the blood pressure and pulse rate. In instances of subcutaneous injury, in which it is felt that the probable injury is that of liver or spleen, the appearance of tender areas remote from the site of injury should be looked upon with suspicion. In the main, operation should be done in all such instances, for a tear in the mesentery or a perforation of the small bowel may be present. Experience with the non operative treatment of bullet wounds of the lung

lends support also to the practice of dealing conservatively with bleeding from intraperitoneal solid viscera. Many surgeons engaged in World War I had an opportunity to satisfy themselves that the conservative plan, on the whole, was safest in such instances.

To be certain in a State University Hospital which draws its injured from varying portions of a large territory, the instances in which the intraperitoneal hemorrhage accompanying abdominal injury has been great, have probably been largely eliminated. Some have died on the spot where the injury was received from a tear of important blood vessels, such as mesenteric vessels, portal vein, or the vena cava, or even the aorta or some of its branches. In the obviously ill patients with complex types of injury, including concomitant chest and head wounds or serious injury to the extremities, in the presence of concurrent suspected fractures of spleen and liver, it has been found wise to treat such patients conservatively. These observations have made it appear even more rational to treat isolated injuries of spleen or liver conservatively, unless a falling blood pressure denoted the continuance of loss of blood. When operative intervention is undertaken for the control of such hemorrhage, the importance of adequate transfusion of blood both before and during the operation can not be stressed too much. It should be remembered that blood loss which causes shock is probably in the neighborhood of 1000 cubic centimeters of blood in an average sized adult.

There will by no means be uniform agreement among surgeons over the plan of conservative treatment of abdominal injuries in the absence of perforation of the gastrointestinal canal. As one examines the literature he can not escape the impression that a more and more conservative attitude is becoming increasingly prevalent among surgeons generally, in dealing with injuries of solid intraperitoneal viscera. The chief difficulty which hedges about the problem concerns largely being certain of the exact nature of the injury. There is, admittedly, opportunity for being wrong—yet the price of satisfying one's curiosity by operation is too frequently bought at too big a premium, with an increased mortality. It is well enough to say that abdominal exploration may be carried out in the chronic abdominal disorder without risk, but unfortunately exploration is not so innocuous in the presence of abdominal hemorrhage which is being spontaneously controlled. With the opening of the peritoneal cavity in such instances, startling acceleration of the bleeding may occur.

The shortcomings of the conservative management of subcutaneous abdominal injury are obvious and the surgeon who employs the method, must be vigilant not to stretch its use beyond reasonable indications. Adequate blood replacement in all cases of hemorrhage before operation is mandatory. In all penetrating or perforating types of injury, early operation is in order.

The agencies which underlie acute abdominal afflictions are essentially (1) perforation (2) obstruction (3) inflammation, (4) hemorrhage and (5) injury. The ultimate consequences of these factors have some effects in common.

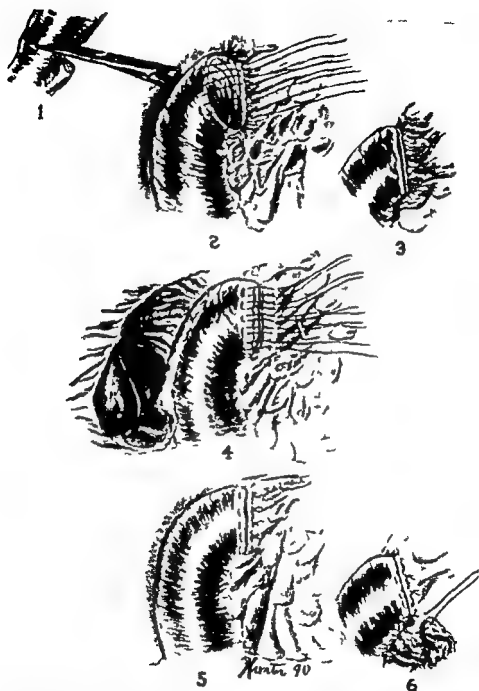


FIG 31.—Closure of the duodenum in the surgical management of massive hemorrhage from bleeding duodenal ulcer. The dissection and separation of the medial (posterior) duodenal wall from the pancreas is the first step. This dissection succeeds in disclosing a perforation in the posterior duodenal wall in massive hemorrhage. The anterior duodenal wall is then cut across totally with scissors as indicated in 1 and the bleeding vessel is ligated. In 2 is shown the placement of interrupted Halsted mattress sutures of fine silk across the open end of the duodenum. None are tied till all are placed. The duodenal walls are approximated as shown in 3 when the

B HEMORRHAGE

The greatest immediate risk to life is in the rupture of a large blood vessel which traverses the abdomen or supplies one of the intraperitoneal viscera. Such an extraordinary accident is directly fatal usually and is rarely susceptible of treatment. Many of the lesser hemorrhages, such as those caused by tears of the liver or spleen secondary to trauma, do not give rise to serious loss of blood and may be repaired spontaneously without the intervention of the surgeon. Continued bleeding in such instances is best reflected in an extension of the signs of peritoneal irritation and a mounting pulse rate; these constitute indications for operation. Hemorrhage occasioned by tears of solid intraperitoneal viscera are not *per se* indications for operation. Traumatic bleeding from mesenteric blood vessels, however, demands early operative relief, not alone on account of loss of blood but even more because of the threatened loss of viability of the gut. The very possibility for occurrence of this sort indicates the danger which lurks in the non-operative treatment of certain types of abdominal injury, unless cases are carefully observed and individualized. No blanket rule can be unfolded which will cover every case. Intraperitoneal bleeding caused by an ectopic pregnancy in a Fallopian tube demands removal of this hazard as soon as its presence can be established definitely. Bleeding from a duodenal or gastric ulcer occurs into the lumen of the alimentary canal and in consequence does not give rise to pain and tenderness common to all intraperitoneal hemorrhages. As a rule, bleeding ulcers are best managed conservatively and a favorable issue usually attends supportive treatment. Careful scrutiny of hospital as well as postmortem records however indicates that fatal hemorrhages from this source are more frequent than is believed generally. In the presence of continued bleeding and a rapid pulse, despite several transfusions of blood, operation is in order. The difficult task of finding and dealing adequately with the bleeding in instances demanding operation is obvious.

Accepted practice has been to regard massive hemorrhage from an ulcer as a medical problem and to invoke operation only for the occasional case. Finsterer (1936) has been long an ardent advocate of operative intervention for the control of active bleeding. More recently Gordon Taylor (1937) of London and Allen (1933) of Boston have advocated a more aggressive surgical attitude toward the patient who is bleeding actively from an ulcer. Too many lives are lost through the *laissez faire* policy. Hemorrhage from ulcer is undoubtedly, one of the few sources of active loss of blood from the body for which the conservative plan of management is advocated. The difficulty lies, however, in the formidable character of the operative intervention necessary to stop the bleeding.

sutures are tied. This closure is by no means as satisfactory as that obtained with the Petz clips and silk suture inversion when there is no posterior wall perforation. However when reinforced as shown in 4, 5 and 6 thereby burying the closed duodenal end in the pancreatic capsule a satisfactory closure usually can be obtained even in difficult cases. Particular note is to be taken of the manner of inverting a closed space on the posterior duodenal wall (6). This is a most important item in the procedure. Such a suture is placed at the upper end as well.

Yet, with adequate blood replacement, prior to and during operation and with satisfactory ligation of the bleeding vessel—a procedure which demands, usually, frank exposure of the ulcer, massive hemorrhage, threatening life, can be dealt with successfully by surgical means. A number of studies have shown that, the mortality of medical management of massive hemorrhage from bleeding ulcer is in the neighborhood of 10 per cent. A goodly number of these patients, who will die, unless bleeding is stopped effectually, can be salvaged by timely operation. The experience of this clinic, in the surgical management of massive hemorrhage, has been very gratifying and has been reported elsewhere (1940).

It has been the writer's practice to perform gastric resection at the same time. The importance of acid in the genesis of ulcer, has been established now beyond question. Once the bleeding is stopped effectually, the operation is withstood. The surgeon who undertakes these operations must stop the bleeding, he must learn also how to close the duodenum satisfactorily (the usual source of the bleeding), under most trying circumstances.

C PERFORATION

Apart from potentially fatal hemorrhages, perforation of the gastrointestinal tract involves the greatest risk to life. Because of its microbial character, breaks in the continuity of the alimentary canal must be considered among the most formidable and menacing of abdominal catastrophes. The most fundamental principle of action in the treatment of acute abdominal lesions is that perforations of the gastrointestinal tract demand immediate closure. Recovery without suture of the defect is decidedly unusual. This guiding rule obtains whether the perforation be the result of blunt trauma, a bullet wound, or a perforated ulcer. Perforations of the stomach and duodenum, if closed early, have a favorable outlook, breaks in the continuity of the lower reaches of the small intestine, and colon, no matter how quickly closed, always take a large toll of life. Allusion was made above to how well unclosed perforation of the stomach was withstood by laboratory animals, if the stomach were empty at the time of perforation. When, however, perforation of the empty stomach is made through an area of inflammation, produced by previous local injection of a sclerosing agent, to imitate the situation, which obtains frequently in perforated ulcer spontaneous closure occurs rarely. Apart from early and satisfactory closure of a perforated ulcer, the items which affect the issue in an important manner are 1) The state of alimentation at the time of perforation, 2) The size of the perforation and 3) The physical condition of the patient.

It is proper to state here, that, perforation of an ulcer is not attended by shock, though prostration may be severe. Shock with quickening of the pulse and depression of the arterial blood pressure, is a sign of hemorrhage.

D OBSTRUCTIONS

No uniform rule can be established concerning the manner of dealing with obstructions. In the main, it may be said that the sequelae which

attend the obstruction determine the choice of procedure. Appendicular obstruction which makes of the appendix a potential closed loop with the attendant dangers of perforation, inherent in all closed intestinal loops, dictates early removal. The importance of obstruction in bringing about perforation of the appendix has been well established. The secretory capacity of the appendix (1 to 3 cc. of fluid a day) accounts for this behavior (Wangensteen & Dennis 1939). Obstruction of the gallbladder may give rise to infection but perforation is not nearly as likely as in the intestinal canal, owing to the absence of normal bacterial flora and an active intrinsic secretory mechanism. Practice has established adequately the rationale of the conservative, non-operative policy in the treatment of most obstructions and infections of the gallbladder; that operative intervention will be necessary in some instances scarcely needs elaboration. Because operative intervention early in acute biliary colic has been compatible with relative safety, some would urge cholecystectomy early in biliary colic as is regularly advised in appendicitis, unmindful apparently of the fact that appendicular obstruction is far more treacherous than is obstruction of the gallbladder. It is the particular purpose of this work to define the guiding principles in the management of bowel obstruction. Whether operative intervention is necessary in urinary tract obstructions will be decided by the grade of interference with urinary flow. Complete obstruction, it is obvious, necessitates removal or circumvention of the block to save life when the arrest is bilateral and complete and to preserve the function of the kidney in unilateral obstructions. Barriers to venous outflow from organs as occur in torsion of bowel or ovary, demand uniformly early operative intervention to minimize blood loss and to obviate the effect of an obstructed circulation, on normal tissues.

E INFLAMMATION

Primary inflammations of intraperitoneal viscera which command the urgent attention of the surgeon are not many. Those infections which demand operative relief are, in the main, probably conditioned by obstruction, e.g., appendicitis and cholecystitis. In the kidney, the full significance of this statement is more readily apparent. The pyogenic infections of the kidney, which are susceptible of relief by surgery, are those due to obstruction. Operation save for removal of the kidney has little to offer patients with pyelitis or pyelonephritis of pyogenic but non-obstructive origin. Some of the first lessons learned concerning the value of conservatism in the treatment of intraperitoneal infections were gained in the management of gonorrheal salpingitis. It is now universal practice to treat acute infections of this nature without operation. The futility of treating puerperal infections by operation is also well known.

Surgeons must recognize their limitations in dealing with inflammation. There are essentially only two indications for operative intervention in the treatment of infection: (1) to prophylactically prevent extension of inflammation from a small focus into a large space—which is probably best exemplified by the removal of an acutely obstructed appendix to

Yet, with adequate blood replacement, prior to and during operation, and with *satisfactory* ligation of the bleeding vessel—a procedure which demands, usually, frank exposure of the ulcer, massive hemorrhage, threatening life, can be dealt with successfully by surgical means. A number of studies have shown that, the mortality of medical management of massive hemorrhage from bleeding ulcer is in the neighborhood of 10 per cent. A goodly number of these patients, who will die, unless bleeding is stopped effectually, can be salvaged by timely operation. The experience of this clinic, in the surgical management of massive hemorrhage, has been very gratifying and has been reported elsewhere (1940).

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a liberal portion finds its way into the distal reaches of an inactive bowel, distension occurs in consequence, absorption is interfered with and the familiar picture of a ballooned bowel, just as effectually blocked as by a mechanical obstacle, dominates the scene

This frequent occurrence in peritonitis has lent the impression that if intestinal distension can be avoided the battle is won With employment of continuous suction applied to an indwelling duodenal tube from the start (before distension occurs) in peritoneal infections, distension can be prevented almost uniformly Enough experience has now been had with the treatment of peritonitis with the aid of this auxiliary, to indicate that, infections in the peritoneum are no exception to those elsewhere in the body Peritonitis to be sure can run a fatal course in the absence of distension That distension may affect peritoneal infection unfavorably is apparent that ileus is the chief cause of death in peritonitis is to be denied This complication of distension in peritonitis can, as a rule, now be dealt with adequately by relatively simple means

The use of sulfonamides in the treatment of peritonitis will show, undoubtedly, some improvement in the results Up until now, most of the results have concerned the use of sulphanilamide in the management of peritonitis accompanying ruptures of the appendix Similarly, sulfonamides have been administered prophylactically to minimize the hazards of peritonitis attending operation upon the large bowel In this clinic, the local implantation of sulfathiazole at the time of operation, is favored This subject will be discussed at greater length subsequently The prevention of peritonitis has proved considerably more successful than its treatment Farr and McFayden (1940) have found the administration of amino acids to children suffering from pneumococcal peritonitis to be an important item in the reduction of mortality

The employment of continuous suction applied to an indwelling duodenal tube widens the scope of the conservative treatment of acute abdominal disorders Suspension of normal intestinal activity accompanies, in some measure every intraperitoneal accident in which fluid escapes into the peritoneal cavity Operative relief was often as urgently compelled by the presence or anticipated occurrence of ileus as by the causative lesion With a readily available and even more effectual agency of dealing with the accompanying ileus than by operation, the necessity for operative intervention is to be determined solely by the nature of the disorder

The excursions of the diaphragm are also automatically restricted in peritonitis and particularly in affections of the upper portion of the peritoneal cavity Complete cessation of its motion, however occurs rarely The secretion of fluid by the mesothelial cells of the peritoneum, in response to the presence of the irritant, furnishes another means of bacterial escape to pread the infection From the site at which the bacteria made their entry into the peritoneal cavity, they are transported passively through this means far beyond the initial confines of the portal of admission If these latter two factors could be as effectually dealt with, as the ileus problem in peritonitis many more victories would be won daily in our conflict with peritonitis

obviate peritonitis, (2) the chief indication for operation in infection is to drain an abscess. It is becoming more and more appreciated that when a surgeon operates for the relief of infection *before* pus has formed, he has not only done an unnecessary operation, but has probably also done actual harm. No longer does one operate upon an abscess of the brain or lung as soon as the diagnosis is made. On the contrary, signs of localization are awaited. The surgeon can not localize an infection, the resistance of the patient must overcome the invading organisms. The surgeon can only do harm by interfering before the tissues have localized the infection and before pus is present. The role of the surgeon in the management of inflammation may be regarded primarily, therefore, as that of a *pus evacuator*. Whereas an antiseptic may be placed on the skin and the surgeon may invade and explore aseptically almost any organ or tissue of the body with impunity, when infection is present, he has no remedy to hold out to the patient, not known to the pre Listerian era. What specific help have aggressive surgical measures lent patients with cellulitis or a pyogenic blood stream infection? Fortunately, for both patients and surgeons, the sulfonamides are accomplishing miracles in the management of some infections—accomplishments that were only dreams before the discovery of these chemotherapeutic agents.

Rest remains still the chief therapeutic adjunct of the surgeon in treating infections in which no localization has occurred. In an extremity, plaster of Paris casts may be applied, with appropriate windows cut in to permit of inspection of the part under observation. Instances have come under the supervision of the writer where amputation has been weighed as the therapeutic expedient most likely to save life—instances in which fever and infection have continued unabated despite generous incision in which instances, immobilization in a plaster cast of the extremity concerned and enough of the body trunk to bring about absolute rest, quickly brought about improvement and relief from pain. Incisions in the absence of collections of pus are unwarranted.

This scheme, which was invoked by V. Bergman (1874) and employed by Dennis (1884) with considerable success in the management of compound fractures, was advocated ardently by Orr (1927) after the first world war as a satisfactory plan for the management of osteomyelitis and compound injuries. It has been employed in this surgical clinic with considerable satisfaction since 1934. It found renewed favor in the war in Spain (Trueta) as well as in World War II.

In the peritoneal cavity, three factors operate to defeat the walling off process with which the peritoneum strives to combat infection. All have to do with motion, the first two with active movement and the other with passive motion, (1) the activity of the bowel, (2) the excursions of the diaphragm, and (3) the secretion of fluid into the peritoneal cavity. In part the organism safeguards itself against the danger of the former by suspending intestinal motility. There are, however, several liters of fluid secreted daily into the upper reaches of the intestinal canal which must be disposed of. With the cessation of intestinal activity some of this fluid can be gotten rid of by vomiting, together with swallowed air, however,

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F PANCREATIC NECROSIS

What the responsible etiological factors are in cases of acute pancreatic necrosis have not been generally agreed upon, though it is known that different types of agencies, especially when operating together, may produce the disease. The surgical treatment of the condition appears, to the writer to be entirely non specific. There have been essentially three things which surgeons have done in its surgical management (1) Drain the peritoneal cavity and remove in as far as practical the intraperitoneal collection of fluid, (2) drain the biliary tract by cholecystostomy or choledochostomy, and (3) tamponade of the pancreas.

Whereas the mechanism which causes pancreatic necrosis may not be well understood, the cause of death can with some assurance be said to be autodigestion of the pancreas. The peritoneal fluid appears to be innocuous on animal inoculation. If the element of infection is an important causative factor, it would appear that in the presence of considerable free fluid in the peritoneum, the insertion of gauze packing or other drains to the pancreas would be a useless agency in delimiting the process. Drainage of the biliary tract in pancreatic necrosis is indicated when an obstruction at the ampulla makes of the choledochus and duct of Wirsung a common channel, permitting the regurgitation of bile into the pancreatic duct. In instances of pancreatic apoplexy with the formation of a large retrogastric hematoma, operation may be employed as a means of staunching the bleeding. Such bleeding however, is but a reflection of the extent of the necrosis, and operation in such instances is usually a futile gesture.

Except in the presence of ampullary obstruction, none of these operative procedures appear to constitute a direct or helpful attack upon the disease. The effort indicated in pancreatic necrosis is an attempt at inhibiting the conversion of trypsinogen into the active ferment, trypsin, within the pancreas. To be certain, the execution of this design is difficult, but it is reasonable that operations which accomplish no specific purpose should be withheld. Stimulation and partial removal of the normal physiological activator of trypsinogen succus entericus, by suction applied to an intubing duodenal tube do not encumber the patient with an added serious burden as does an operation, which fails of specific accomplishment. Morton (1940) has advocated and employed, with some success, irradiation with x rays as a means of inhibiting pancreatic secretion in the management of pancreatic necrosis.

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CHAPTER V

ADJUVANT (INDIRECT) MEASURES IN THE TREATMENT OF BOWEL OBSTRUCTION

ONCE the diagnosis of intestinal obstruction is established, the most important question to decide is what agency should be employed in its relief. Of the available therapeutic procedures, only two affect the obstructive process directly, viz., operation and suction applied to an intubing duodenal tube. The other remedial measures of merit in the management of obstruction are essentially supportive agencies and are of particular value where a consequence of obstruction arises which calls for their use, these are infusion of saline solution, transfusions of blood and plasma and inhalation of high concentrations of oxygen (Fine and associates 1935-1936). The former is a great vitalizer in many states, but when vomiting has been prominent the liberal administration of saline solution is mandatory. So similarly with transfusion of blood, it may be used to advantage frequently without strict indication. In strangulating types of obstruction where the patient's pulse is rapid because of loss of blood into the infarcted segment, blood transfusion acts like a restorative. Similarly, where a high grade of distension has diminished the effective circulatory blood volume transfusion of plasma is an expedient of value. In those instances of strangulating obstruction in which the pulse is rapid because the viability of the bowel wall is lost and transperitoneal absorption from the lumen is occurring, transfusion is a laudable but impotent gesture.

Agents which enhance the contractile activity of the bowel have no place in the management of mechanical obstructions. Their role in the treatment of the distension of physiological obstruction will be subsequently discussed. It may here well be noted that the remedial measures which have established their worth in the relief of obstruction ask only a passive role of the bowel.

It will be the purpose of this section to define what the therapeutic values of these agents are, what indications denote their employment, what their shortcomings are, together with an account of what may be expected of each agent.

A SALINE SOLUTION

The success of saline solution in prolonging the lives of dogs with high obstruction afforded clinicians considerable hope that it would prove a great boon to patients with bowel obstruction. As has already been pointed out however saline solution even in dogs exerts the virtues of a specific only in high obstructions, in the lower varieties, it exhibits no special merit. Most obstructions observed clinically occur relatively low in the intestine. In consequence very little specific help is to be expected in bowel obstruction by the administration of saline solution alone. In pyloric obstructions attending duodenal ulcer and in the temporary obstructions occasionally observed at the stoma after gastrojejunostomy

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or gastric resection, the free administration of saline solution has proved of great value. Whereas the dehydration occurring in bowel obstruction is satisfactorily combated by saline solution, it exerts no real favorable influence on the course of the obstruction.

Although no specific improvement attends the employment of saline solution in many obstructions, nevertheless, the importance of this agent in bettering the patient's general condition is not to be underrated. It has been stated previously that patients with bowel obstruction have oliguria. In high obstructions with profuse vomiting attended by the loss of considerable fluids and electrolytes, oliguria and even anuria may be observed. When the blood chlorides fall to a low level, no sodium chloride is available for excretion and urine is not put out. When the depleted chlorides are replenished and fluid is given, the excretion of urine begins again. In low obstructions, interference with absorption and lack of a normal fluid intake are responsible largely for the oliguria observed. The free administration of saline solution restores the general bodily state of the patient.

Enough saline solution should be given to insure a daily urine output of 700 to 1000 cubic centimeters in which the presence of a total of about 3 grams sodium chloride may be demonstrated. Paine and Armstrong (1939) point out that sodium chloride is a threshold substance and amounts given, beyond the body needs, are excreted. The daily excretion of a satisfactory quantity of urine constitutes a reliable index of the presence of a normal tissue fluid balance, and the excretion of 3 grams of sodium chloride daily in the urine suggests that the patient is also in satisfactory sodium chloride balance. In low obstructions attended by great distention, the too liberal administration of saline solution may result in greater accumulation of fluid within the bowel, for Baylis and Starling (1894) have shown that the intravenous administration of saline solution increases greatly the capillary pressure in the intestinal vessels attended by a similar increase in portal pressure and flow in lymph. In the presence of a falling blood pressure, Blalock, Beard and Thuss (1932) and accompanying local injury to the intestine. Beard and Blalock (1932) found that intravenous injections of glucose or saline solutions were attended by an increase of loss of plasma protein through the capillary wall.

Sodium chloride balance The most accurate index of the sodium chloride balance is determination of the plasma chloride level in the blood. Normal values for sodium chloride in the plasma run from 560 to 600 mg per cent. Coller and his associates (1938) have suggested that, for each 100 mg per cent that the plasma chlorides need to be raised, to reach the normal minimum value of 560 mm per cent the patient be given 5 gram of sodium chloride per kilo of body weight. In a patient weighing 70 kilos and in whom the plasma chloride value is found to be 460 mg per cent, the patient will need $560 - 460 = 100 \times 5 \times 70 = 35$ grams of sodium chloride to bring the value up to the normal of 560 mg per cent. These predicted calculated values coincide quite accurately with clinical trials. Overchlorination of patients which results from the too liberal use of saline solution, causes salt retention and edema. For each 9 grams of salt

administered, beyond the body needs, if the excess salt is not eliminated in the urine or by sweating 1,000 cc of fluid accumulates in the extracellular fluid spaces

Status of hydration and water requirements The status of hydration of the patient can not be determined as accurately as the status of chlorination. In the main, however, thirst of the patient, dryness of the skin and tissue turgor are satisfactory indices of the status of hydration. In patients presenting no disturbance in fluid balance, on admission to hospital, the status of hydration may be maintained with considerable precision during the postoperative period by weighing the patient (page 243). Obstructed patients who give a story of considerable vomiting, and, who present obvious evidences of fluid loss should have early and adequate replacement of such losses. Coller and Maddock (1940) have suggested the following guides for orientation of the surgeon in the determination of the amount of fluid required daily for 24 hour periods by surgical patients

TABLE XV—WATER REQUIREMENTS OF SURGICAL PATIENTS

A The uncomplicated surgical case		
1 Water for urine—water necessary to provide a satisfactory daily output of specific gravity in the optimal range of 1.015		1000 cc
2 Water for vaporization—water necessary to replace fluid lost by vaporization from skin and lungs	1000 cc to	1500 cc
TOTAL	2000 cc to	2500 cc
B For the complicated case (fever, hyperthyroidism, hot humid weather and intestinal obstruction)		
1 Water for urine	1000 cc to	1500 cc
2 Water for vaporization		2000 cc
3 Water necessary to replace fluid lost by vomiting, aspiration from intubing, duodenal tube drainage from biliary and intestinal fistulae, diarrhea, blood loss and exudation from areas of increased capillary permeability (areas of inflammation or threatened loss of viability)		X variable
TOTAL	3,000 cc +	variable X

Item 3 in patients with obstruction of the small intestine is usually a consideration of the greatest importance. Coller and Maddock believe that patients who present manifest evidences of dehydration have lost 6 per cent of their body weight. In a patient weighing 70 kilos 4200 cc of water would have to be given under item 3 to replace the 6 per cent weight loss owing to vomiting and lack of fluid intake by a patient with obstruction high in the small intestine.

The excretion of a satisfactory amount of urine with a specific gravity within the normal range (1.012 to 1.020) gives adequate assurance that the fluid requirement of the patient has been met. There are hazards of overhydration, as well as of underhydration, particularly in the old patient, who has a poor cardiac reserve. Some of the factors bearing on this issue, such as the quantity, quality, and route of fluid, will be discussed subsequently in Chapter IX on Post operative Treatment.

Water of vaporization is divided between skin and lung losses. Ordinarily, the losses of water through renal and extrarenal channels are divided equally, about a liter being lost through each (Gregerson 1938). Adolph (1931) estimates the loss of water by vaporization from the lungs as constituting about 30 per cent of the extrarenal losses (see Table 1, page 9). The insensible cutaneous loss of water and that lost by respiration are continuous processes which go forward at an approximately constant rate. Loss of water through the kidneys and the sweat glands fluctuates normally, within very wide ranges.

In obstructed patients, presenting evidences of dehydration, the intravenous administration of 5 per cent glucose in saline solution is in order. When a satisfactory urine flow has been established, the subcutaneous route may supplant, in part, intravenous injections of saline solution. Addition of glucose to the saline solution helps to combat the ketosis which accompanies starvation. The problem of meeting the caloric and nitrogen needs of the patient, in addition to the generally recognized water and electrolyte requirements, will be discussed at length subsequently (Chapter IX).

D BLOOD AND PLASMA TRANSFUSIONS

The blood loss factor in all strangulating obstructions may be a consideration of some moment. Into a gut, in which the wall is the seat of hemorrhagic infarction, considerable blood may be lost, especially if that segment be long. Blood is lost into the lumen as well as into the wall of the bowel. In volvulus, intussusception, strangulated hernias, adhesive obstructions with compromise of the blood flow and mesenteric thrombosis the blood loss factor may be a significant item. Whereas blood volume reductions of 20 per cent have been described by Herrin and Mecl in dogs with thirty fistulas artificially distended to simulate the condition present in obstruction, the actual blood loss is not great, and clinical trial demonstrates the futility of expecting a favorable influence upon the course of simple obstruction by replenishing the depleted blood volume, alone, whether with plasma or blood. However, in all simple obstructions accompanied by great distension, transfusion of blood or plasma proves to have value in that it meets the plasma loss factor satisfactorily. In chronic obstructions, in which the plasma proteins may be low because of prolonged inanition, transfusions of plasma are in order to repair this deficiency.

In any patient with a strangulating obstruction in whom the pulse is weak or the blood pressure is at or near the shock level, the transfusion of blood or plasma is indicated. In the case of shock and depleted protein that hemolytic reactions have occurred attending blood loss, blood is superior to plasma. In chronic obstructions, in which the plasma proteins are low because of prolonged inanition, transfusions of plasma are in order to repair this deficiency.

In any patient with a strangulating obstruction in whom the pulse is hurried or the blood pressure is at or near the shock level the transfusion of blood and plasma is indicated.

The following case illustrates well the occurrence of blood loss in a strangulating obstruction. A female child of eighteen months was admitted to hospital with an invagination of the bowel of 72 hours' duration. The pulse was feeble and extremely rapid, the rate being about 200 per minute. No improvement attended the subcutaneous administration of 300 cubic centimeters of saline solution. After being brought to the operating room, 500 cubic centimeters of saline solution was given intravenously without favorable effect upon the pulse, whereupon 300 cubic centimeters of citrated blood was administered through the same needle. The pulse became stronger and slowed to 160. Ether was administered and a compound intussusception (entero enteric and ileocolic) was found and reduced. The Meckel's diverticulum which constituted the apex of the intussusception was amputated. The telescoped gut wall was thick and diffusely red, but fortunately, appeared to be viable. The patient convalesced uneventfully. Without adequate blood replacement, such a patient could not have been operated upon safely. No patient with a strangulating obstruction in which the pulse is hurried should be submitted to operation without preliminary transfusion of blood or plasma in adequate amounts.

C INHALATION OF HIGH CONCENTRATIONS OF OXYGEN

In 1936 Fine and his associates suggested that, inhalation of high concentrations of oxygen would help to combat intestinal distension and that this agency would prove useful in the treatment of mechanical as well as inhibitive paralytic types of ileus. Fine's thesis is based on the relatively high tension of nitrogen present normally in the blood plasma. Inasmuch as nitrogen constitutes roughly 80 per cent of air it is obvious that the tension of nitrogen in the alveolar air will be

$$80\% \text{ of } 760 \text{ mm Hg} = 47 \text{ mm Hg (water vapor pressure at } 37^\circ)$$

$$80 \times 713 \text{ mm Hg} = 570 \text{ mm Hg}$$

By reducing materially the amount of nitrogen in the gas inhaled, by substituting oxygen for it, the tension of nitrogen in the alveolar air may be made to fall to zero. In consequence, the nitrogen in the bowel may be caused to be given up from the intestinal lumen for exhalation by the lungs. Wright (1939) states the solubility of the respiratory gases in 100 cc of plasma at 38°C and 760 mm Hg pressure is as follows: CO_2 , 54.1 cc; oxygen 2.8 cc; and nitrogen 1.1 cc. Despite this low coefficient of diffusion it is obvious that Fine's concept of transport of nitrogen across the intestinal mucosa from the lumen of the bowel is sound. Nitrogen, despite the low coefficient of diffusion, constitutes 70 per cent of the gas in the obstructed bowel and it is apparent that, with the elapse of time, significant amounts of intestinal gas may be removed by this expedient. Fine and his associates and Paine have demonstrated conclusively in the dog that established distensions accompanying mechanical obstructions may be influenced favorably by the inhalation of high concentrations of oxygen.

In this clinic, however, the impression has been gained, that in order to be effective, this expedient must be accompanied by the use of suction applied to an indwelling duodenal tube, for, otherwise, one intestinal gas is probably replaced by swallowed increments of another gas.

Paine and his associates (1941) who have given serious study to the general problem of influencing the absorption of gas from the intestine by the inhalation of high concentrations of oxygen have observed that, normal (unobstructed) dogs may be killed regularly by the uninterrupted administration of oxygen in concentrations above 70 per cent. A severe inflammation is set up in the lungs and the dogs die of pulmonary edema. In addition, necrosis in the liver occurs. Paine has not, as yet, clarified how occasional interruptions may modify this serious potential complication of inhalation of high concentrations of oxygen in the management of intestinal distension. It is to be noted further that Paine's observations have been made only on the dog. Yet, his observations corroborate the old impression held by physiologists viz. that inhalation of high concentrations of oxygen may cause desquamation of pulmonary epithelium.

Lovelace (1941) has suggested recently that more than one atmosphere of pressure may be used to augment the rate of migration of intestinal gas across the intestinal epithelium. It is obvious that this suggestion necessitates the use of special apparatus to avoid the hazards of employment of pressure greater than one atmosphere.

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CHAPTER VI

DECOMPRESSION BY APPLICATION OF SUCTION TO DUODENAL TUBES IN OBSTRUCTION

A FACTORS SUGGESTING USE OF CONSERVATIVE DECOMPRESSION

From determinations made upon fluid escape occurring through an enterostomy tube from a gut obstructed by adhesions, it was observed frequently that, after an initial escape of small amounts of gas and fluid, the gut established again its own continuity with little or no subsequent drainage. On the contrary, instances were observed in which the drainage was profuse and continued independent of the site at which the drainage vent had been established. It was reasoned, therefore, that the continuance of profuse drainage following high jejunostomy or low enterostomy was dependent on the persistence of a high degree of obstruction, that minimal escape of gas or fluid through an enterostomy tube indicated that the obstructive mechanism must have relented.

These observations suggested the possibility of decompressing the gut in certain instances of mechanical obstruction without operation. The observations with relation to the fluid lost through an enterostomy have been extended since the employment of suction has been applied to an intubing duodenal tube to include gas escape as well. The impression first gained that the quantity and continuance of escape are correlated with the degree of the obstruction and not with the site at which the enterostomy was made have been borne out fully (Table XVI).

TABLE XVI—FLUID DRAINAGE THROUGH TUBE FOLLOWING ENTEROSTOMY FOR ACUTE INTESTINAL OBSTRUCTION

CASE I (Mrs E H)

Preoperative diagnosis Acute adhesive obstruction complete as indicated by Fig 26

Duration 4 days

Procedure Enterostomy in lower ileum

Postoperative day

Drainage through enterostomy tube (cc)

1	375
2	200
3	85
4	0
5	0

Outcome Satisfactory; dismissed 21 days after operation

Comment Obstructing mechanism must have soon relented following the establishment of drainage

CASE II (Mrs C R)

Diagnosis Partial obstruction due to adhesive band

"

Prostomy

TABLE XVI—FLUID DRAINAGE THROUGH TUBE FOLLOWING ENTEROSTOMY FOR ACUTE INTESTINAL OBSTRUCTION (*Continued*)

Po toperative day	Drainage through enterostomy tube (cc)
1	250
2	15
3	5
4	20
5	200
6	150
7	100
8	75
9	50
10	75
11	50
12	100
Outcome	Recovery

CASE III (Mrs B Z)

Preoperative diagnosis Partial obstruction due to adhesion

Duration 20 hours

Procedure Enterostomy

Po toperative day

Drainage through enterostomy tube (cc)

1	0
2	0
3	20
4	65
5	180
6	60

Outcome Recovery

CASE IV (Mr A M)

Preoperative diagnosis Strangulating obstruction caused by adhesive band

Duration 3 days

Procedure Exteriorization of 24 inches of gangrenous bowel in mid ileum. Catheters placed in both proximal and distal ends

Postoperative day

Drainage through proximal catheter (cc)

1	1700	
2	2450	
3	1500	
4	1700	
5	0	(escape of fluid around catheter)
6	500	
7	400	

Outcome Recovery with successful closure of fistula 2 months later

CASE IV (Mr A M)—Second admission

Preoperative diagnosis Strangulation obstruction caused by adhesive bands

Duration 22 hours

Procedure Enterostomy 18 inches distal to duodeno-jejunal angle with division of adhesive band. Bowel viable

INTESTINAL OBSTRUCTIONS

TABLE VII—FLUID DRAINAGE THROUGH TUBE FOLLOWING ENTEROSTOMY FOR ACUTE INTESTINAL OBSTRUCTION (Continued)

Postoperative day	Drainage through enterostomy tube (cc)
1	90
2	25
3	10
4	5
5	10
6	5

Outcome Recovery

Comment On first admission the fluid drainage represents the quantity lost through a complete fistula. On the second admission though the enterostomy was high the drainage was slight in amount.

The observations, made before suction applied to an indwelling duodenal tube was employed as an agency in the treatment of mechanical obstructions have been confirmed since, with the addition that simultaneous measurements of gaseous escape have been made as well. In the main, the quantity of gas aspirated through an enterostomy catheter, like the amount of fluid drainage, is dependent largely on the grade of obstruction present. The removal of a small amount of gas or fluid near the obstruction may be followed by spontaneous restoration of intestinal continuity. In this connection, it is interesting to note that exteriorization of the lower ileum, in an unobstructed patient for removal of a carcinoma of the cecum, in accordance with Iaher's (1932) adaptation of the Bloch-Paul Mikulicz operation, may be unattended by fluid or gaseous drainage initially for periods exceeding 24 hours in length. This occurrence is owing, no doubt, to the paralytic effect of operation and anesthesia upon the bowel and is a factor that must be reckoned with in all operations directed at the relief of obstruction.

An opportunity for trial of suction applied to a duodenal tube was afforded in the summer of 1931 in the instance of a seventy-two year old lady admitted to hospital late at night with an obstruction of 72 hours' duration. The patient was dehydrated badly and the systolic blood pressure was 80 millimeters of mercury. The distension was considerable as revealed by the roentgenogram. It was apparent also from the film that the entire small intestine was dilated. Past experience had taught that saline solution alone did not improve materially the condition of such a patient as an operative risk and the hazard of relieving the obstruction by operation was quite obvious. Not without a feeling of some timidity a duodenal tube was passed into the stomach and attached to a source of continuous mild suction. Saline solution was administered subcutaneously and the foot of the patient's bed was elevated.

The next morning the patient's condition was found to be improved notably. Two hundred cubic centimeters of fluid and 800 cubic centimeters of gas had been aspirated during the night. A film taken eight hours after the first showed marked reduction in distension. After 40 hours suction the decompression was complete. Because of the conjectured persistent nature of the obstruction (believed to be carcinoma of the cecum) operation was performed. A stricture of the terminal ileum probably myphilitic



FIG 32—Decompression by suction applied to an indwelling duodenal tube in a high grade low ileal obstruction Mrs E J aged 72 (a) Radiograph of abdomen on admission to hospital 72 hours after onset of obstruction Moderate distension of entire small intestine is present the patient generally was in poor condition (b) After 8 hours suction during which time 200 cubic centimeters of fluid and 800 cubic centimeters of gas were aspirated (c) After 40 hours suction decompression is complete Because of the conjectured nature of the obstruction (thought probably to be carcinoma of the cecum) operation was done A stricture of the terminal ileum was found incised and invaginated into the cecum The patient recovered

in nature was found The stricture was divided in the longitudinal axis of the bowel the strictured area was invaginated into the cecum, and a proximal enterostomy was done, following which the patient convalesced uneventfully

The Rationale of Conservative Decompression

John Hunter is said to have related to Edward Jenner, "Try the experiment don't think" Direct experimentation will probably always have an important place in all human activity Rationalization without recourse to analysis of accepted premises by direct experiment leads one into errors frequently, not often because the deductions are fallacious, but

rather because the premises themselves are invalid. One occasionally finds himself saying, "Is not that quite obvious? Why didn't I think of that before?" If all the factual data bearing on the issue were available and known to the one attempting rationalizations, there would be little need for direct experiment. Mathematicians and logicians then, who would take the time to become thoroughly acquainted with the subject under discussion, could deliver a satisfactory and accurate answer to any question propounded them.

When, however, the result of experiment is conclusive and unequivocal, it may be rationalized readily and the significance of its constituent components may be properly appraised.

As has been related previously, the chief sources of distension in the obstructed bowel are swallowed air and fluid dumped in at the gateway of the intestinal canal, viz, gastric and pancreatic juice, bile, and succus entericus. In the presence of high grade interference with the continuity of the bowel, regurgitation of the stagnant intestinal content into the stomach and upper reaches of the intestine is an invariable occurrence. It is immediately apparent that as fluid and gas accumulate in the stomach they may be removed readily by intubation. The mechanism of effectual decompression of the lower reaches of distended small intestine by this means, however, is not so obvious. The small intestine of the adult is an elastic tube of about twenty or more feet in length. The activity of the pyloric sphincter interrupts the continuity of the stomach and small intestine as a single simple tube. Not uncommonly, however, this sphincter fails to present a physiologic block for decompression of the small intestine by a tube lying in the stomach. Moreover, it is found to be a distinct advantage, in influencing the distension favorably, to have the tube pass beyond the pylorus, well into the small intestine. A catheter with a somewhat stiff tip appears to enter the duodenum more readily than the soft tube.

In the intestine of the intact dog or in the human gut excised at necropsy, it may be demonstrated readily following the introduction of air or water into the intestine that the exertion of suction on one end is immediately appreciated in the same degree at the other end. When, however, a mixture of gas and fluid is present, the difficulty well known to physicists whether dealing with rigid or elastic tubes comes into play. In simple gaseous or fluid distension, the entire intestine may be decompressed almost at once. When segments of gut are found alternately distended with gas and fluid, decompression will be effected only slowly.

The Necessity for the Use of Suction

The alimentary canal is unique among the tubular organs and cavities of the body in that both gas and fluid are concomitantly present under normal conditions. When the bowel is obstructed large accumulations of both fluid and gas are the rule. It has been said occasionally that, an intubating duodenal tube will serve the desired ends equally as well as the addition of suction to the tube.

The verity of such a contention may be submitted easily to experimental inquiry. The efficacy of an intubating duodenal tube employed as a simple

siphon may be tested readily by measuring the fluid that drains away, no opportunity however is afforded for determining its worth in the removal of gases because of their escape. By employing a Mariotte bottle for the collection of the gas aspirated, the efficiency of simple siphonage for the removal of gas may be determined also. The construction of the bottle is such that the pressure of the atmosphere is always present at the end of the tube in which the fluid and gas are delivered by the duodenal tube from the stomach.

By alternating siphonage and suction in patients who had been operated

TABLE XVII—QUANTITIES OF FLUID AND GAS REMOVED BY ALTERNATING SIPHONAGE AND SUCTION (Paine and Wangenstein 1933)

Time	Siphonage		Suction	
	Gas cc	Fluid cc	Gas cc	Fluid cc
4 hrs 30 min			750	50
8 hrs 30 min	25	175		
10 min			50	250
4 hrs 55 min	0	0	500	200
10 min	0	0		
1 hr 50 min	0	0	0	11
10 min	0	0	0	600
3 hrs 55 min	0	0		
10 min			800	600
2 hrs 30 min	75	325		
10 min				
5 hrs 50 min	0	0	400	500
10 min				
2 hrs 15 min			200	400
10 min				
11 hrs 25 min	0	0	200	200
10 min				

on for a variety of abdominal disorders, it was demonstrated readily that suction was considerably more effectual than siphonage (Paine and Wangenstein 1933). Frequently as much gas and fluid were aspirated in ten minutes when the duodenal tube was attached to a source of mild but continuous suction as had been aspirated in as many hours when the tube was attached to a Mariotte bottle acting as a simple siphon.

The fluid and gas escape in a patient from whom the gallbladder had been removed, treated with alternating suction and siphonage as indicated in the accompanying table (Table XVII) may be considered as quite typical of the comparative efficacy of these two agents in providing for the removal of gas and fluid from the upper reaches of the intestinal canal and stomach by an intlying duodenal tube.

Similarly x ray examinations made of the abdomen of patients with intestinal distension before and after the employment of siphonage and suction attest the greater efficiency of the latter in influencing the distension favorably.

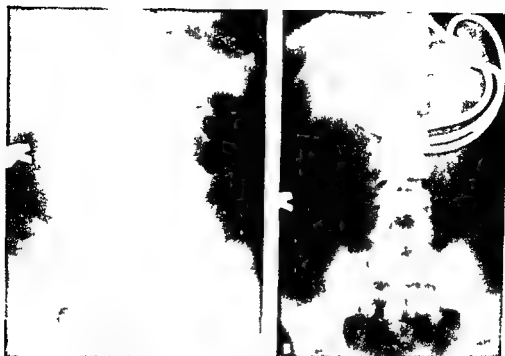
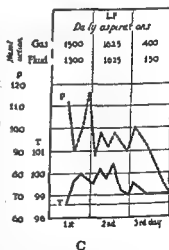


FIG 33—Decompression after three hours of suction in a complete jejunal obstruction L F a boy of 9 years (a) Radiograph of abdomen on admission after 48 hours of intestinal colic and vomiting The obstruction concerns the upper third of the small intestine apparently and is complete no gas being visualized in the colon after the administration of evacuant enema (b) After 20 hours suction decompression is complete A film taken 3 hours after the commencement of suction indicated that the distension had been influenced favorably already To avoid any delusion concerning the existence of the obstruction exploratory laparotomy was done 15 days later An adhesive band was found binding the gut and its mesentery down to the posterior parietal peritoneum at about the location deduced from the initial film The band was divided and the patient was dismissed 14 days later (c) The graph indicates the pulse and temperature reaction during the time that suction was employed also the quantities of fluid and gas aspirated



As a matter of fact, this is what one would expect should happen, bearing in mind the mechanics of siphonage. The successful operation of a water siphon depends upon the existence of two vertical columns of fluid of unequal height connected at the top. Both columns of water have the pressure of an atmosphere exerting itself on their lower ends, but since one column is longer and therefore heavier than the other it pulls the shorter column in its direction. A negative pressure then obtains at the end of the shorter tube which equals in grams per square centimeter the difference in height of the two columns of water in centimeters. If gas enters the system, the siphonage action ceases immediately since the dif-

ference in height of the two columns of water no longer exists. A few bubbles of gas may pass through without interrupting the action of the siphon but a very small quantity (20 cubic centimeters) of gas will effectively interfere and break the siphonage.

Removal of the contents of the distended stomach and intestine by an inkling duodenal tube operating as a simple siphon is of necessity bound to be ineffectual. Siphonage is unsuited for the removal of fluid where gas is also present. The entry of a column of gas into the siphon interrupts its action which can only occur spontaneously again when fluid accumulates in the stomach under sufficient pressure to force the gas out. Similarly, the application of suction to the longer tube will again restore its activity.

The Degree of Suction Necessary

Although the alimentary canal establishes communication with the body surface at both its origin and termination it is essentially a closed system because of the various sphincters and particularly the cardiac sphincter of the esophagus and the ileocolic and external sphincters of the rectum. Being a closed system it is apparent that the only reason it may be decompressed by suction is that the gastro intestinal tube is elastic. Its walls may collapse when negative pressure is exerted upon its interior through this occurrence alone can the content of a distended stomach and intestine be evacuated by suction. Were the walls of the gastrointestinal canal as unyielding as an empyema cavity in which thickening of the visceral pleura precluded expansion of the lung its content could not be removed by suction. Despite employment of an enormous negative pressure in the instance of the empyema cavity first referred to unless the force were great enough to actually pull out the lung or cave in the chest wall, its entire content could not be evacuated by suction.

Still in the very elasticity of the intestinal tube resides one of the hindrances to the employment of great negative pressures viz the engagement of the mucosa of the stomach and bowel in the perforations of the duodenal tube. This may be overcome in part by the use of multiple perforations in the tube but is best regulated by the use of continuous mild suction. From clinical trial and experimental test on the stomach and intestine of the dog and cat, 75 centimeters of water (2 1/2 feet) would appear to be within the optimal range of negative pressure.

Inasmuch as the intestine from the standpoint of the employment of suction is a closed tube a simple water siphon which is regulated easily constitutes probably the best of the available varieties of suction. Intermittent suction with a hand syringe is not very satisfactory.

The Hydrodynamics of Negative Pressure Applied to Rigid and Elastic Tubes

Paine (1936) has given special study to the mechanics of achieving decompression. It has been indicated previously that when the intestine of the dog is filled with either water or air, it may be emptied readily by suction applied at one end. Similarly, a series of rigid glass U tubes arranged in a continuous circuit of vertical columns if filled with water can



FIG. 34.—Radiographs and charted course of a patient in whom decompression by suction was effected after fifty five hours. Mr. A. W. aged 35 developed gas pains on the day on which he was to have been discharged from the hospital following appendectomy for acute suppurative appendicitis. Distension had been present occasionally during his convalescence but was not of the grade demanding suction. (a) X ray film of abdomen taken after the first spell of copious vomiting 14 hours after the onset of gas pains. Enemas had been given and no gas is visible in the colon. (b) Film taken 13 hours after the commencement of suction. The stomach is empty but there has been no appreciable reduction in the degree of distension of the obstructed bowel. (c) After 44 hours of suction. The existing distension has been con-

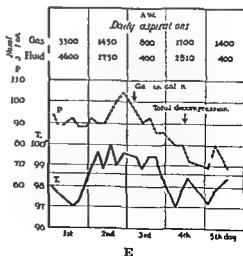
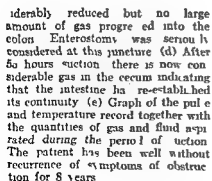
be emptied if suction is applied at one end, granted that the other is open. If the other end is closed, however, very little fluid can be removed no matter what suction is applied. It has been indicated already that even in a closed system, the gut, when distended with either air or fluid, may be emptied readily because of the elasticity of its wall.

The effectiveness of negative pressure in the presence of interspersed segments of air and water is tested readily in both rigid and elastic tubes by direct experiment. A series of three glass U tubes as mentioned above and arranged in a continuous circuit, provided with pet cocks, were filled with water in their lower halves while air occupied the upper halves of the tube. Mercury manometers were attached at either end and suction was applied at one end, A, while the other end B, was open. Twelve centimeters of negative mercury pressure was applied at A. The pressure registered at B was 37 centimeters negative pressure. The difference or 83 centimeters of mercury pressure had been taken up in the system and was represented by the difference in heights of the columns of fluid.

A similar loss of effectual pressure in the elastic tube of the intestine is readily shown in attempting to remove by suction interspersed air and water injected into the gut of the dog or cat. Considerable experimentation was done upon this phase of the problem in order to evaluate the technical difficulties concerned.

The findings were quite uniform and the following experiment typifies the usual result. Fifty cubic centimeter quantities of air and water were injected alternately at various levels in the small intestine of the dog. The terminal ileum was tied and a duodenal tube introduced through the stomach was pushed into the duodenum. Water manometers were attached to cannulas placed in the distended gut at four evenly spaced sites between the duodenal tube and the obstruction. A uniform pressure of 38 centimeters of water was established by the intra-enteric injections of 800 cubic

FIG 34 (Continued)



centimeters of air and water. When 75 centimeters of water suction was applied, 225 cubic centimeters of gas and fluid were aspirated immediately and the pressure in the proximal cannula fell to 10 centimeters. The pressures registered in the next, in sequence were 12, 15, and 14 centimeters of water respectively. Despite continuance of suction for 10 minutes or increase of the degree of negative pressure applied, no more fluid or gas was evacuated. It is observed, therefore that inter-persion of gas and fluid interrupts effectually the ability of continued suction to evacuate the bowel. Alteration in the position of the various coils rearranged the gaseous and fluid collections and permitted again the aspiration of a small quantity of gas and fluid.

The reductions in pressure observed in clinical cases of obstruction attending the use of suction probably occur in the same proportion as was obtained in these animals, the only difference being that the initial pressures in small bowel obstruction are likely to be in the vicinity of 10 centimeters of water. Were the gut a closed rigid tube containing fluid alone, which is incompressible, the removal of a few cubic centimeters might cause an enormous pressure to drop to zero. The gut, an elastic tube, on the contrary contains compressible gas and incompressible fluid, and just to what extent an existing intra enteric pressure will be influenced by the aspiration of a portion of the content cannot be predicted in any given instance.

The usual quantity of these aspirations is indicated in the graphs accompanying the pulse and temperature reactions. No water was permitted these patients by mouth, so that the fluid readings are accurate. In the instance of the gas aspirated corrections will have to be made for pressure and temperature. The gas in the bottle when the readings are made is under a negative pressure of 75 centimeters of water and consequently expands. Within the gut the gas is at body temperature and so is greater in volume than when measured at room temperature. These two factors practically offset one another, however.

Measures Which Aid Decompression Where It Does Not Quickly Occur

When suction is long continued, the churning action of an active turbulent bowel and the absorption of some fluid from the gut which occurs with the elapse of time, and changes in posture and manipulation of the abdominal wall help to disarrange the existing interspersed collections of fluid and gas and so facilitate decompression. If the small intestine were a large reservoir as the stomach or even a single uncoiled tube the decompression of interspersed segments of gas and fluid would be accomplished easily. It would appear that the absorption of fluid from the gut might be facilitated through intravenous injections of concentrated solutions of acacia (30 per cent) by increasing the osmotic pressure of the blood. Trials with such a method proved ineffectual, for though the osmotic pressure of the blood could be definitely influenced by this means, no appreciable increase of fluid absorption from the gut occurred.

Use of the Müller Abbott tube, a double lumen and balloon tipped tube,

to facilitate decompression of the distended bowel will be discussed below in a separate caption

II INDICATIONS FOR THE EMPLOYMENT OF DECOMPRESSION BY SUCTION

The decision as to what agency is to be selected in securing relief of the obstruction is obvious when the obstruction is strangulating in nature or an obstruction of the colon with great distension is present. In either instance, early operation is urgently indicated. When, however, the obstruction is simple in character and concerns the small intestine the determination of the best remedial measure may be no easy task. In the main it may be said that a trial with suction applied to an intubing duodenal tube is permissible in those cases in which clear indication for immediate operation does not exist. If the distension be not great and the obstruction is incomplete, it is likely that decompression may be achieved by these means without operation. Adhesive obstructions are especially amenable to treatment by conservative decompression in that partial evacuation of the bowel will frequently permit of automatic reestablishment of intestinal continuity. It is apparent that the removal of a quantity of gas and fluid near the site of obstruction will bring about such an adjustment more readily than removal of the same amount from the upper reaches of the intestinal canal. In defense of suction applied to an intubing duodenal tube however it may be said that such drainage on the whole is usually considerably more liberal than from a catheter after enterostomy.

Mechanical Obstructions: Experience with the automatic establishment of intestinal continuity of the obstructed gut after decompression by enterostomy suggests that obstructions due to adhesions in which no strangulating mechanism obtains should be ideally suited to its use. Trial with the method bears out this inference and indicates that almost invariably incomplete simple adhesive obstructions whether of remote or recent origin may be satisfactorily dealt with by suction applied to an intubing duodenal tube. Not infrequently complete adhesive obstructions have to be decompressed by enterotomy after a preliminary trial with suction applied to a duodenal tube indicates that the obstructive mechanism does not relent. The obstructive element observed in inflammatory lesions and particularly when masses are present constitutes a frequent indication for which the method usually adequately suffices. Suction may be employed with advantage in a large number of obstructions of the small intestine in which the strangulating element is absent. In fairly complete obstructions, however in which the probable nature of the obstructing agent is such that spontaneous reestablishment of intestinal continuity will not follow decompression suction should not be persisted in long. In such instance when whatever improvement attends decompression of the upper reaches of the intestine has been attained, recourse should be had to operation.

The writer has always been timid over prolonged conservative management of instances of simple mechanical obstruction of the small intestine when no operative scars are present on the abdomen. True enough, an

adhesive obstruction may be present in the absence of such scars and similarly a previous operative scar affords no absolute assurance that adhesive bands are responsible for the obstruction. Nevertheless, the possibility of procrastinating in instances of an enteric intussusception or obstruction due to a gallstone in the bowel is considerably lessened if this guide is kept in mind. These are essentially the two varieties of simple obstruction which can not be identified readily and which may be confused with simple obstruction caused by an adhesive band. Congenital atresia of the intestine of the newborn is usually easily identified, as is ordinarily a stricture of the small intestine whether due to a neoplasm or a benign process.

An obstructive agency which appears to relent, occasioning the patient to feel better temporarily and then renews itself again with repetitions of this sequence, is very likely to be due to an incarcerated gallstone. In part, the temporary relief is due to the dilatation of the gut about the stone, in part, to onward descent with renewed impaction. The writer has diagnosed bowel obstruction due to an impacted gallstone correctly on the basis of this sequence of events in the absence of a previous history of gallbladder disease or of events which would suggest the presence of an internal biliary fistula. Whenever the slightest suspicion exists that a type of obstruction is present which will demand operative relief, as soon as whatever pre operative treatment appears indicated has been carried out, operation should be done.

It can not be too vigorously emphasized that he who elects to treat a patient with mechanical obstruction conservatively must follow the decompression by subsequent x ray films. Whereas this precaution is not so important in physiological obstructions, the writer believes that the clinical criteria of relief from pain and seeming improvement are not sufficiently accurate indices of whether the obstruction is relenting. It is scarcely necessary to add that he has constantly practised what he believes and here advocates.

As a guiding rule, it may be stated that, if progressive decompression is not manifest within twenty four to thirty six hours after the commencement of effectual suction, operation is in order. This delay will permit of two to three check-up bed side films being made in the interval. Increase of intestinal distension demands operation. On occasions and especially during earlier years the writer has continued suction for a longer period than this and noted no special ill effects from this delay. A safer rule, however, is to operate when a reasonable trial with suction has proved it ineffectual. Even in those obstructions in which it is immediately apparent that operation is the only agency which will afford satisfactory and adequate relief the simultaneous employment of suction is desirable, not alone because it affords a means of evacuating the stomach and upper reaches of the small intestine but also in that incidental to operation and entry into the peritoneal cavity there is superimposed a temporary paresis of the gut, which added burden suction effectually combats. Strangulating obstructions and acute occlusions of the colon with considerable distension will brook no delay with conservative measures of treatment. Patients

with such obstructions should be submitted to immediate operation, when their general physical status permits

Functional Obstructions In the functional obstructions of nervous imbalance, whether due to inhibitive (paralytic) or spastic ileus, decompression by suction applied to indwelling duodenal and rectal tubes is usually attended with success. Occasionally, however and particularly when dealing with peritonitis, suction appears to affect the existing distension but slightly. In such instances on the whole as indicated by the lack of distension attending early employment of suction in postoperative cases in which distension would ordinarily occur, prophylaxis against further distension appears to be more readily attained than ablation of the existing distension. Nevertheless the success of suction in controlling distension in peritonitis has shown that the patients may die from their peritoneal infection. The impression held in many quarters that patients with peritonitis die largely because of intestinal distension has been set aside adequately by a large number of instances in which suction did away satisfactorily with the distension but the patients succumbed still to their peritoneal infection

In a number of cases of inhibitive (paralytic) ileus, the judicious employment of smooth muscle stimulants serves as a useful auxiliary to duodenal and rectal suction in the relief of distension. The bowel wall is not paralyzed as the term "paralytic ileus" would imply. The contractile activity of the bowel is inhibited by an overactive nervous system. As Hotz (1909) showed experimentally the distended gut of peritonitis will contract when stimulated by a balloon placed within its lumen. Spinal and plumbic anesthesia will compel frequently an expulsion of gas and feces in the distension of peritonitis as described by Ochsner and his associates (1930), and others. On the whole, however it should rarely be necessary to have recourse to these somewhat drastic expedients. Hypertonic saline solution, as advocated by Hotz (1909) and Hughson and Scarff (1924) as well as ephrin, prostigmine and pituitary extract are usually effectual. Even these agents are to be employed with caution in peritonitis because of the danger of disseminating the infection. Nevertheless their use is fraught with considerably less risk than operation which seldom does much good but frequently does succeed in spreading the infection.

Other Conditions in which the Employment of Suction Is Indicated

Whenever abdominal distension exists from whatever cause suction applied to an indwelling duodenal tube is a valuable instrument in combating it. The physiological obstructions whether they accompany operation, infection, injury or a miscellaneous group of conditions are usually most effectually dealt with by suction exerted on an indwelling duodenal tube. This agency is gradually supplanting the employment of enemas as a more effective remedial measure in the treatment of distension. It has been pointed out already that the use of enema in the presence of intraperitoneal suppuration is hazardous. The distension accompanying uremia, pneumonia, diabetic coma and fracture, whether of the spinal

column with associated injury of the spinal cord, or pelvis, ribs, or femurs, is best dealt with by suction. Retroperitoneal hemorrhage or infection and thoracoplasty are among conditions which may give rise to considerable distension. Inhibition of intestinal activity in some degree attends every intraperitoneal invasion, whether it be by the surgeon, infection, hemorrhage, or leakage from the alimentary canal. With reference to the employment of suction after operation, it is to be remembered that, suction is more effectual in the prophylaxis of distension than it is in contending with such physiological obstructions after the establishment of distension. In operations upon the stomach, biliary tract, or spleen, in which the occurrence of distension is to be anticipated, routine employment of suction will insure almost invariably a convalescence free from this complication. It is also of value in diminishing the tension upon an intestinal suture line. The application of suction to an indwelling duodenal tube is a worthwhile procedure in the performance of colostomy in that it permits of greater delay in opening the bowel. With frequent use of suction applied to an indwelling duodenal tube, the dreaded acute dilatation of the stomach after operation has ceased to exist.

Suction serves an extremely important purpose in combating distension attending the occasional complication of evisceration through vertical incisions. With the aid of a small dose of an appropriate intravenous anesthetic (pentothal sodium), the intestines are returned to the abdomen, a piece of rubber dam (Penrose drain) is led through the wound and liberal adhesive strapping is applied. The drain carries away the secretion and the adhesive strapping remains firm for the requisite period of time, usually about two weeks. No sutures are placed. The employment of suction deals satisfactorily with the obstructive element, in the main, as firm abdominal walls are obtained as with secondary closure and more lives are saved. Since vertical abdominal incisions in this clinic have been closed with interrupted sutures of fine buried silk, evisceration has become an extremely rare occurrence. Substitution of oblique or transverse, for vertical incisions, and closure with interrupted sutures of fine silk has practically eliminated evisceration as a complication of elective abdominal surgery in this clinic.

In combating the night pain of patients hospitalized for the treatment of uncomplicated gastric or duodenal ulcer, suction has been found effectual. The removal of gastric juice secreted when food is not taken during sleep obviates the occurrence of these pains. Suction is useful also in keeping the stomach empty in the presence of gastric hemorrhage from an ulcer. If a large intragastric hematoma is allowed to accumulate, perforation of the thinned out ulcerated area is more likely to occur—a complication which has twice come to the writer's attention in cases treated "medically" in which water by mouth had been withheld. The employment of suction apparently does not increase the bleeding, the duodenal tube should be irrigated frequently enough to permit of aspirating the blood. However, suction is not to be considered a substitute for surgical intervention to arrest hemorrhage, in the presence of active massive hemorrhage from a bleeding duodenal ulcer.

Contraindications to Suction

There are essentially two absolute contraindications to the employment of suction as the sole active remedial agent in dealing with bowel obstruction, viz (1) strangulating obstructions with compromise of the blood supply, and (2) acute obstruction of the colon with enormous distension of the proximal colon. The latter being converted into a closed loop type of obstruction, by the proximal competent ileocolic valve and sphincter is as previously related, essentially a strangulating obstruction. In all such instances, decompression of the distended colon by operation is in order. In partial obstructions of the colon with lesser grades of distension suction applied to an intubing duodenal tube in obviating further distension from the upper reaches of the intestine, frequently permits of dealing with the lesion in the gut in a non obstructive phase.

It is probably not amiss at this juncture to say something concerning the alleged more serious character of high obstructions as contrasted with the low. Though this impression should have been corrected adequately with the knowledge that the loss of electrolytes and essential fluids constitutes the special hazard in high obstructions, this opinion is still encountered amongst clinicians. Saline solution counteracts the evil effects of these losses. The easier evacuation of the upper reaches of the intestine by vomiting precludes the development of distension and the high intra-enteric pressures observed in lower obstructions. Probably the most vicious type of obstruction observed clinically is that which occurs acutely in the pelvic colon. There is frequently no vomiting and no loss of fluid. The only finding may be an enormous distension. As has been described, this is essentially a closed loop obstruction with a high intra enteric pressure. Unless relieved the colon may perforate. The dictum that the high obstructions are the most perilous should be amended to read that low obstructions on the contrary, are more dangerous because of their effects on the bowel wall.

C TECHNIQUE OF THE EMPLOYMENT OF SUCTION

The sphincters of the stomach and esophagus make of the upper portion of the gastrointestinal tube a closed system. In consequence a simple water siphon as shown in the accompanying diagram (Figs 35, 36), constitutes a satisfactory source for effectual suction. It is to be noted that the catheter employed (Fig 37) has holes cut back over a distance of 23 centimeters. The entrance of the distal end of the catheter into the duodenum is to be desired, in order that simultaneous suction may be exerted on both the stomach and duodenum. In event that the catheter remains in the esophagus and does not enter the stomach or is regurgitated back into the esophagus suction will be ineffectual. As is indicated below routine practice in this clinic in the management of mechanical obstruction is to employ the Miller-Abbott tube for once this tube has entered the duodenum, its migration into lower reaches of the intestinal canal, facilitates and ensures earlier decompression.

Passing the Catheter

The duodenal tube with the urethral tip (Ievin duodenal tube) can be inserted usually without causing the patient any distress. Before the lubricated tip of the catheter is introduced into one of the nares, the patient is asked to take a sip of water through a drinking tube. This water is held in

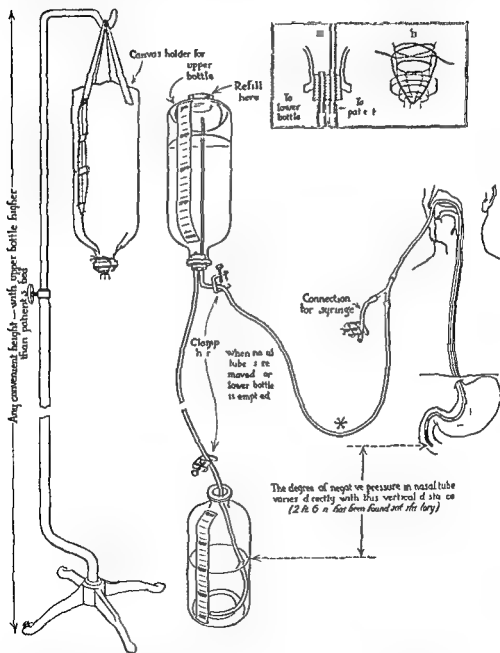


FIG 35—Suction apparatus for gastro-duodenal siphonage. A trap bottle is always used when the fluid returns are large (Transactions Western Surgical Association 1931 and West J Surg 40 1 1932)

the mouth and is only swallowed as the tip of the tube is advanced through the nasopharynx and is felt by the patient in the throat, at this juncture he takes more water through the drinking tube and swallows it as the tube is introduced. This manner of inserting the catheter permits almost invariably of its accomplishment without discomfort to the patient. Preliminary spraying of the oral pharynx with cocaine has had to be resorted to on very rare occasions. Infants may be gaged usually without difficulty. In order to facilitate entry of the tube into the duodenum a catheter with a leaded-tip has been made up (Figure 37). As soon as the tube has entered the stomach, the clamp on the water siphon is removed and the contents of the stomach are evacuated by suction. When the stomach is empty as determined by the return of clear water on further swallowing the action of the suction is interrupted by clamping the rubber tube leading to either bottle the patient is turned on his right side and the catheter is advanced two to three centimeters every five minutes. The end of the catheter being heavy and the stomach empty it is hoped that this maneuver will bring the catheter into the vicinity of the pylorus. The patient is now permitted to drink about half a tumbler of water. As the water leaves the stomach entry of the catheter into the duodenum is favored. In this manner the duodenum can be intubated with fair regularity. After half an hour when the duodenal tube has been advanced fifteen to twenty centimeters more the tip should be well into the duodenum. Unless distension is very great, this maneuver in the main proves quite successful. Inhalation by the patient of an ampoule of amyl nitrite broken into a handkerchief aid relaxation of the pyloric sphincter. The catheter should not be attached to the cheek and upper lip with adhesive tape until the catheter has been advanced well into the duodenum. It is advisable at this juncture to secure evidence by fluoroscope or an x ray film as to where the tip of the catheter is. Granted that it is in the duodenum efforts should be made to advance it well into the small bowel. If the initial tube is not long enough another may be fastened on at the

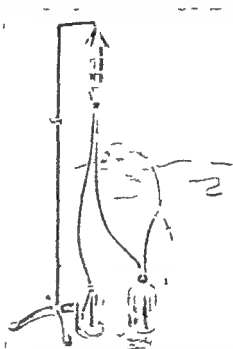


FIG. 36.—Three bottle suction apparatus. The Pottenger rubber connection, are employed to cap the suction bottles. The force of suction when a trap bottle is employed is determined by the distance between bottles 2 and 3 (See Fig. 35.)

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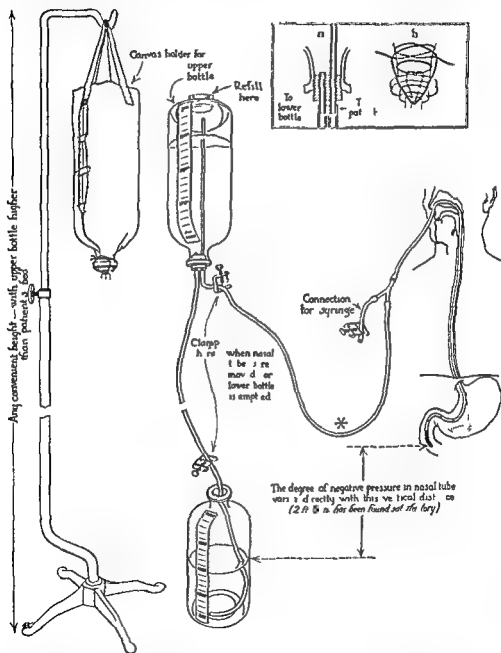


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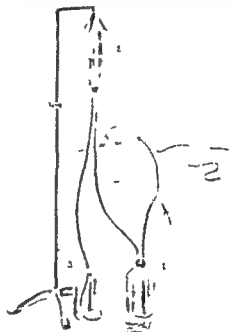


FIG 36—Three bottle suction apparatus. The Pottenger rubber connections are employed to cap the suction bottles. The force of suction when a trap bottle is employed is determined by the distance between bottles 2 and 3. (See Fig 35.)

oral end. In mechanical obstruction of the small intestine, regurgitation from the intestinal canal into the stomach occurs with regularity. In consequence, the color and reaction of the returned fluid is not as accurate an indication of the position of the tube as is this same criterion in unobstructed patients. The first x-ray film taken some hours after the commencement of suction will give reliable evidence on this point. Attempts have been made with this tube with the heavy leaded tip to intubate the duodenum with the aid of the fluoroscope as an initial step. On the whole, however, not enough is gained to make it worth the effort as a routine procedure. If, however, duodenal intubation can not be achieved in the manner described, a trial with fluoroscopic control is in order. In physiological obstructions, entry of the tube into the duodenum does not appear to be so important for successful decompression. Because of the multiple perforations extending over a considerable length of the tube, it is apparent that as the catheter begins to exhibit signs of wear, that it becomes unsuitable for employment in instances of mechanical obstruction, the tendency of the tube to bend at one of the perforations proximal to the leaded tip causes the course of the tube in the stomach to be deflected away from the gastric pathway of the lesser curvature.

Additional Schemes to Intubate the Duodenum

Development of measures more certain to succeed in the intubation of the duodenum, are very much to be desired. Hay (1941), of this clinic, has worked with a flexible adjustable cylindrical tube which is passed into the stomach. The tip of the instrument may be pulled into the vicinity of the pylorus, under fluoroscopic control. This object being relieved, a duodenal tube may then be passed through the cylindrical tube into the pyloric canal. If this scheme proves practical it should be a great boon to intubation of the duodenum and to use of the Miller-Abbott tube.

Paine (1933) suggested, without trying some years ago the use of a magnet to facilitate entry of a tube into the duodenum. On a visit to the Kirschner surgical clinic in Tübingen in 1928 Willy Usadel pointed out to the writer, a large discarded electromagnet which Payr had employed with the intent of severing (or pulling apart) intestinal adhesions bloodlessly without recourse to operation. Kirschner had implanted steel balls beneath the skin, the alleged purpose being to elevate skin flaps, with the use of the electromagnet. According to Usadel, experiment showed both these dreams to be bubbles. These considerations suggested to the writer that Paine's idea of intubating the duodenum by employing an electromagnet had little merit to recommend it. Gius (1941) has the impression, from preliminary trials, that a duodenal tube mounted with a suitable bucket possessing magnetic properties, may be directed into the duodenum, despite the insulating qualities of the abdominal wall.

Doss (1938) attached small lead shot, attached by a short thread 6 to 10 inches in length, as a leader to the tip of the duodenal tube—the thought being that the lead shot would enter the duodenum and pull the duodenal tube after it. Smith (1941) has worked with the same scheme also. As a matter of fact, the lead shot entered the duodenum quite readily. Subse-

quent manipulation of the tube succeeds, however, only in pulling the lead shot back into the stomach. Some variant of this scheme may result also in facilitating entry of the tube into the duodenum (See caption on the Miller Abbott tube and its use below.)

The Apparatus

The materials necessary for the construction of a water siphon which will supply an active source of suction suitable for use in aspirating gas and fluid from the stomach and intestine are readily available in any hospital and an intern can assemble the apparatus easily. Two large bottles which can be graduated and so connected with rubber tubing that water can run from the lower position of the upper to the lower bottle constitute such a source for active suction. When the upper bottle and the rubber tube leading down to the lower bottle are filled with water and the distal end of this tube is submerged beneath a short column of water in the lower bottle the apparatus is ready for action. The tube which leads from the duodenal catheter to the upper bottle should have a Y connection so that one may readily perceive by opening this side arm whether the suction apparatus is working properly. It affords also a means of irrigating the duodenal tube which is very likely to become plugged with mucus or other aspirated content if this precaution is not observed. When the return from the stomach contains thick tenacious flocks frequent irrigation of the tube is necessary to keep it open. A warm solution of soda affords a good solvent for mucus. If a patient with obstruction continues to have nausea or vomiting the tube is either plugged or it is not in a satisfactory position. If the tube can be irrigated freely but there is no return of fluid with the suction open the lower end of the tube is probably in the esophagus. A critical and minute attention to these particulars is very important.

In instances in which the amount of fluid aspirated is great, it is always well to insert a trap bottle in which the fluid aspirated from the stomach may be collected directly. Especially is this important when the suction is prolonged over a considerable period of time. A portion of this collected fluid may then be returned again by proctoclysis. Of the fluids removed by aspiration the gastric and pancreatic juices are undoubtedly the most important. Total loss of gastric juice is incompatible with life (Walters Kilgore and Bollmann) so similarly with pancreatic juice (Elman and McCaughan). Bile, though important for normal health, is not absolutely



FIG. 37.—Duodenal tube with multiple perforations and lead tip employed at the University of Minnesota Hospital for the relief of distention.

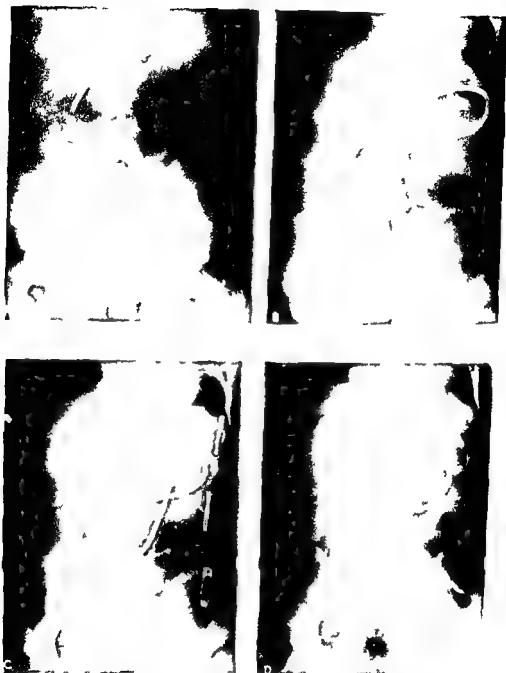


FIG 38—Enterostomy employed to complement duodenal siphonage because of the appearance of symptoms suggesting strangulation Mrs A G aged 44 had a hysterectomy performed 8 years ago Admitted with a 72 hour history of obstruction (a) Film showing grade and extent of distension a few hours after institution of suction The leaded tip of the tube is entering the duodenum (b) Considerable reduction in distension after 72 hours suction there is no gas in the colon however and slight rebound tenderness is present suggesting the necessity for operative intervention (c) Radiograph made directly following enterostomy a slight amount of clear fluid was present in the peritoneal cavity (d) Twenty four hours after enteros-

necessary for the maintenance of life (Whipple). The liberal administration of saline solution will supplant adequately at least temporarily the loss of gastric juice through a complete gastric fistula. Animals can not be kept alive indefinitely by any known means when all the pancreatic juice escapes through a fistula. If however a dog with such a preparation is allowed to lick the fistulous opening and thus ingest some of the pancreatic ferment he may survive such loss. Whenever the fluid returns by siphonage are great it is very important therefore to catch the fluid in a separate trap bottle and return a portion of it through an enterostomy catheter or by proctocolysis. When such a third bottle is inserted about 200

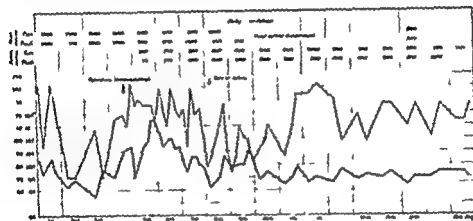


FIG. 32c

cubic centimeters of air, trial has demonstrated must be removed by siphonage before the suction becomes apparent on the duodenal tube. When the water in the top bottle has run out it may be filled by taking it off the sling and refilling it or through the special hole made at the top for the purpose (Fig. 32c). Singleton of Galveston has suggested in erection of a Y directly between the tube leading to the top bottle and the tube leading away from it. This permits of collection of the aspirated fluid in the bottom bottle and the accumulation of gas in the upper bottle. Pratt suspends the bottles on a portable stand with a large T arm in such a manner that either tube might be easily elevated or lowered. The gas escapes through a special valve and can not therefore be measured. In more recent years a number of other modifications in assembly of the apparatus have been suggested. Because of the simplicity and ready availability of the apparatus described above it appears to meet adequately all the conditions of convenience. The total cost of the materials in the siphon apparatus employed at the University Hospital is about a dollar.

Whenever indication exists for the employment of suction the volume of tomy gas is present in the colon. The patient has remained well. (e) The graph indicates the pulse and temperature reaction attending the employment of suction and the performance of operation. The lesser drainage following enterostomy indicates that the bowel has released itself from the obstructing agent.

fluid and gas removed should be determined. Especially is this important when the fluid return is great. Whatever fluid is aspirated must be subtracted from the *fluid intake*. The aspirated fluid then serves not only as a measure of the grade of obstruction present but also as an important factor in determining how much fluid should be administered. At the University Hospital (Minneapolis) it has been routine practice to employ 4 liter bottles. Suction is arbitrarily commenced for purposes of uniformity with 400 cubic centimeters in the bottom bottle. Gradations in amounts of 200 cubic centimeters are marked in ink on a strip of adhesive tape and fastened on the bottles. For every centimeter of gas or fluid aspirated, a centimeter of water is displaced into the lower bottle. The gas aspirated remains in the top bottle, if the return was wholly fluid, there would be no change in the level of the water column in the top bottle, for every centimeter of water displaced another centimeter of aspirated fluid would take its place. Hence, the amount of gas aspirated may be read directly, from the net sum of fluid displacement into the lower bottle, the gas reading is subtracted, this remainder indicates the fluid aspirated. These computations should be made every 24 hours (6 00 A M) and charted by the nurse as indicated in Figure 72. These directions concern computations of fluid and gas aspirations in a two bottle suction apparatus (Fig. 35). In a three-bottle apparatus which is being used more and more, the aspirated fluid collects in the trap bottle (Fig. 36) and the gas collects in the upper bottle.

Einhorn (1940) stated recently that the type of black tipped leaded tube illustrated here (Figures 35, 36, and 37) with multiple perforation is ineffectual in emptying the stomach. Einhorn, it appears, failed to weigh the difference in behavior between rigid bottles with open necks and a contractile stomach and duodenum with physiologically active sphincters in the esophagus. Einhorn's statement is disaffirmed further by the success attending use of this type of tube in effecting decompression of the upper gastro intestinal canal, in a number of hands. When some of the perforations lie above the fluid level, air will be sucked out of the stomach before fluid is removed. Schwyzer (1939) and Smith (1941) have confirmed the verity of this contention by experimental trials on a contractile stomach, distended with air and fluid.

How Long Is Suction to Be Continued?

In mechanical obstruction, inspection of x ray films made at the bedside at 12 to 24 hour intervals, after the commencement of suction, and the amounts of gas and fluid returned by aspiration furnish good evidence as to the progress of the decompression and determine also whether operation is necessary. Before removing the duodenal tube, it is always a good plan to interrupt the suction for intervals of increased lengths of time. When clear fluids can be taken and no distress is occasioned after suction has been discontinued a few times over a period of three or four hours, it is safe to remove the tube.

In the use of suction to obviate the occurrence of gaseous distension after operation, the same indication is to be observed for the discontinu-

ance of siphonage. Patients learn to release the clamp on the tube themselves not infrequently when interruption of suction causes them distress. Occasionally, it is necessary in peritonitis to leave the duodenal tube in for several weeks, alternating suction and oral intake of clear fluids before the normal motility and transport power of the bowel have become fully re-established.

In the relief of distension by the employment of suction the question suggests itself naturally as to how far a duodenal tube may be passed down into the bowel. A number of years ago McClendon observed that a small tube could be made to enter the lower reaches of the ileum. In a text of a later date (1925) a roentgen film indicating the position of the tube is shown. McClendon found that a tube 7 feet (2.13 meters) in length reached from the teeth to the terminal ileum in an adult. Van der Reis and Schembra have indicated also that the physiological length of the gut is considerably shorter than the anatomic lengths of which we are more accustomed to think. Not uncommonly after the tube enters the duodenum after operation as well as in mechanical obstructions treated conservatively the distal end of the tube is observed to have made its way well into the jejunum. The tube which the writer has employed most commonly (Figure 37) has perforations extending proximally from its distal tip for a distance of only 27 centimeters (10.6 inches). Inasmuch as it is important to exert suction simultaneously on both the stomach and the small bowel in instances in which it is deemed especially desirable to have the catheter enter the lower reaches of the jejunum or even the ileum the precaution is to be observed of employing a tube with perforations extending well proximally. At first glance it might appear that suction employing a closed system would be ineffectual until all of the tube containing perforations had passed beyond the cardiac sphincter of the esophagus. Such, however, is not ordinarily the case. The superior sphincter in the cervical esophagus suffices to maintain the closed system intact. Only rarely does a water siphon system "leak" when a portion of the perforated tube remains within the esophagus. Van der Reis and Schembra have succeeded in passing tubes throughout the entire length of the intestinal canal. Entry of the duodenal tube into the upper jejunal coils occurs not uncommonly in mechanical obstructions treated conservatively. It would therefore appear that in certain types of mechanical obstruction in which the time element is of no great concern that the extent to which the principle of suction may be employed is limited only by the persistence and ingenuity of the surgeon and the endurance of the patient.

The Miller-Abbott Tube and Its Use

In 1934 Miller and Abbott developed a double lumen, balloon tipped duodenal tube for intubation of the small intestine. In 1938 Abbott and Johnston announced the passage of this tube well down into the lower reaches of the bowel, in patients with mechanical obstruction of the small intestine. They observed that following intubation of the duodenum inflation of the small balloon at the tip, stimulated the gut to contract down upon it and propel the balloon and duodenal tube in a forward direction.

down the bowel. After the balloon tipped catheter (Fig 39) has entered the duodenum, it is amazing how quickly it may be propelled down the bowel sometimes. In a few instances, it has been impossible to get the tip of the catheter beyond the duodeno jejunal angle, despite frequent change of posture by the patient, or deflating or increasing the inflation of the tube. The more serious obstacle to achieving quick decompression with the Miller-Abbott tube, however, is difficulty which concerns the more frequent case, in which it takes a long time, and even days to get the tube out of the stomach. In some of these patients, decompression is achieved by suction applied to the indwelling gastric tube, while passage of the tube out of the stomach is awaited. Unfortunately, in the patients with the greatest distension, in which quick intubation of the duodenum is

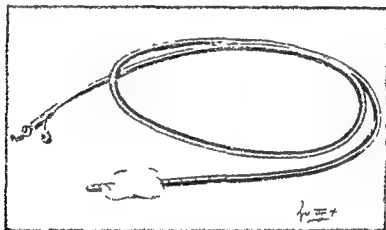


FIG 39—The Miller Abbott double lumen balloon tipped tube for intestinal intubation

most important, in these very patients, the greatest difficulty is had, almost invariably. The greater the distension, apparently, the greater the difficulty in securing early migration of the tube out of the stomach. The best scheme for duodenal intubation is essentially the same as with the ordinary duodenal tube, the balloon being deflated, of course, until the duodenum has been entered. There are a few cases in which the tube moves down the bowel satisfactorily, but in which subsequent x-ray films reveal persistently distended coils of small intestine, that can not be decompressed. Such patients need an enterostomy to effect satisfactory relief from obstruction. Occasionally, retention will occur in the stomach, despite migration of the catheter well into the lower reaches of the obstructed intestine. In such instances, an additional catheter may have to be placed in the stomach and left in place for a few hours each day.

Despite many obvious shortcomings, the long, balloon-tipped duodenal tube has been a great boon to extension of the advantages of conservative decompression to certain types of obstruction. The indications and contraindications for its use, are essentially the same as for the ordinary duodenal tube. The chief advantage in its use lies in the quicker decompression which

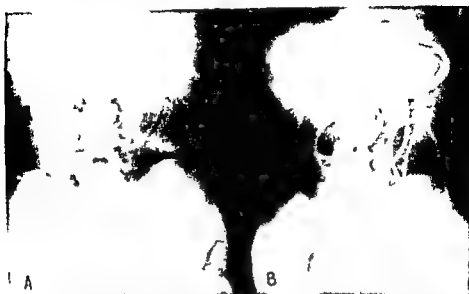


FIG 40—High grade obstruction relieved by Miller Abbott tube (a) Distension on entry to hospital. The obstruction appears to be complete (b) Complete decompression achieved after 48 hours. Another duodenal tube was inserted into stomach to allay vomiting. The tube stayed in situ several days and the patient continued to eat without manifesting signs of obstruction. However on withdrawal of the tube the patient reobstructed. Suction was ineffectual and enterostomy had to be done. Eventually partial enterectomy was done because of the complicated character of the obstructing mechanism. The patient has remained well.



FIG 41—Miller Abbott tube in decompressing obstructed bowel (a) Extent of distension. The patient had been obstructed several hours on arrival (b) Partial decompression achieved by the Miller Abbott tube still lying in duodenum—after 120 hours (c) Complete decompression was not achieved until suction had been in force for more than 10 days. An ordinary duodenal tube has been inserted into the stomach because of the occurrence of gastric distension and vomiting. The wisdom of carrying on attempts at effecting decompression by conservative means so long is open to serious doubt.

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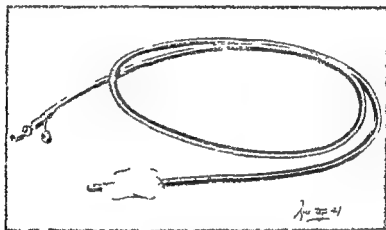


FIG 39—The Miller Abbott double lumen balloon tipped tube for intestinal intubation

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advantage in Svertsen's suggestion concerning the employment of mercury lies in the extremely mobile character of mercury. Employing a funnel, one can pour mercury (1 to 2 cc) easily into the small tube leading to the balloon, and the greater portion of it can be expressed again from the balloon. Should the balloon break in its transit through the intestinal canal no harm would ensue from the presence of this amount of



FIG. 42—Use of the Miller Abbott tube in locating an occult intrinsic obstruction in the bowel. The defect between the arrows was due to a carcinoma of the retroperitoneal duodenum. It was excised successfully.

mercury within the bowel. It remains to be determined how practical this suggestion will be.

Other Uses of the Miller Abbott Tube

In addition to the patient presenting acute intestinal obstruction, the Miller Abbott tube is of special value in preparing the patient for operation with recurrent obstruction. For, with the tube well into the lower reaches of the small bowel, suction may be expressed there to allay distension, the patient being permitted to eat meanwhile. Patients who have had repeated episodes of obstruction and a long period of starvation are notably poor risks for operation. One such patient with a very fatty liver came under the writer's notice. A protracted period of simultaneous feeding of a high protein and carbohydrate diet while suction was in force would have averted this error. Johnston and his associates have pointed out the greater ease of maintaining fluid balance in patients having this type of suction, as contrasted with patients having the tube lying in the duodenum.

Some surgeons notably Whipple (1940) employ the Miller Abbott tube regularly in resections of the colon, feeling that the advantages of a complementary enterostomy are provided therewith. In this clinic, it has

attends intubation of the lower reaches of the small intestine. In this clinic, we have come to employ the Miller-Abbott tube regularly in all obstructions which appear suitable for relief by conservative decompression. Yet, in the three-year period, during which the Miller-Abbott tube has been used regularly, in this clinic, the incidence of successful decompression, without recourse to operation, has not been greater than it was with the use of the ordinary duodenal tube, previously. Nevertheless, in all obstructions, in which the objective is to decompress the distended intestine, the Miller-Abbott tube should be employed routinely. During the past year, in this clinic, the tendency in the management of cases, with great distension, which respond slowly to conservative means of decompression has been to veer away from too protracted efforts at achieving decompression in this manner. Timely and well executed surgery holds out less risk to such patients. If efforts at conservative decompression are persisted in too long, the distended lower reaches of the bowel are damaged and the patient comes to operation a worse risk than if operation had been performed earlier. The risks of decompression by conservative means mount only, if the method fails. Successful decompression by the conservative method carries, as reports from this and other clinics (Abbott and Johnston (1938), Johnston and associates (1938) and Leigh, Nelson and Swenson (1940)) a very low risk. How many patients die eventually from operation because suction was persisted in, too long is not determined readily. Without question, it is an item that deserves consideration. Suction has taught that decompression without spillage is synonymous with success. The surgeon must learn also how to achieve decompression *without spillage* in those cases in which operation is mandatory.

Latterly (October 1941), Abbott has described a method of intubating the duodenum with employment of the long, balloon tipped tube, which promises to enhance the usefulness of the conservative method of achieving decompression. Abbott employs a piece of piano wire with a diameter of 4 mm. Two feet proximal to the balloon, the side of the Miller-Abbott tube is perforated with the wire, which then follows the lumen of the tube, terminating just proximal to the suction holes in the catheter. A small twist in the wire at the site of entry of the wire into the Miller-Abbott tube prevents it from moving forward within the lumen of the tube. Under the fluoroscope this stiffening of the proximal reaches of the Miller-Abbott tube permits, not uncommonly, immediate entry of the duodenum by the tube. In this clinic, this scheme suggested recently by Abbott has been employed with more satisfaction than other techniques described previously to facilitate entry of the duodenum by the Miller-Abbott tube.

It is interesting that twenty years and more ago, before development of the urethral tipped duodenal tube of Levin (1921), every duodenal tube came equipped with such a wire stylet to facilitate passing of the duodenal tube by mouth. A discarded useful technique of the past has been resurrected and put to good use again.

Sivertsen (1941) suggested to the writer that, placement of metallic mercury into the balloon of the Miller-Abbott tube would facilitate entry of the tube into the duodenum. Lead is used for this purpose in the black tipped tube. The atomic weight of mercury is 200, that of lead 207. The

distension, (3) the visualization of gas in the colon on the x ray film in complete obstructions, indicating that the obstruction has been overcome, (4) less fluid aspirated through the duodenal tube, denoting that stasis is no longer prominent, and (5) toleration of temporary discontinuance of suction without recurrence of pain.

With reference to cessation of pain following the institution of suction one caution is to be observed—viz., that the bowel having accommodated itself to a certain grade of distension, no accretion occurring, in that the swallowed air and fluids discharged into the duodenum being removed by suction, which increments would otherwise augment the distension, the patient may not be conscious of any painful contractions. In all mechanical obstructions treated by suction, therefore, it is highly important to have an x ray film every twelve or twenty four hours, depending on circumstances, to be certain that the caliber of the distended gut is actually becoming smaller.

No narcotics need or should be given these patients. Continued pain indicates that decompression is not adequate by the method. It is a good plan however to apply heat to the abdomen. It is routine practice in this clinic, to give 5 to 1 grain (30 to 60 mg.) sodium luminal hypodermically three times a day (adult dose), while suction is in force to obtund the sensibility of the patient to the irritation in the throat, occasioned by the presence of the tube. (See Section I below.)

D. SHORTCOMINGS OF SUCTION

Apart from the mechanical handicaps described previously, there are two inherent weaknesses in this method of treating mechanical obstruction with suction alone. (1) Drainage of the gut is done at a point remote from the site of obstruction, necessitating the removal of a much greater quantity of gas and fluid to permit of the intestine automatically adjusting itself and re-establishing its continuity than if the gut had been drained by enterostomy near the point of obstruction. (2) In the interval during which one waits for the obstructing mechanism to relent, the gut above the obstruction cannot be employed as a nutritive tube as it can when the gut is drained near the point of obstruction. The Miller Abbott tube however, circumvents this latter difficulty in that the patient may eat with the tube in place, after decompression has been effected.

E. THE RESULTS OF CONSERVATIVE DECOMPRESSION

The results of any method of treatment are best evaluated in its successes and failures. The obstructions in which suction has its widest field of usefulness are the adhesive variety, where drainage of the bowel may permit automatic re-establishment of intestinal continuity. Suction has come to displace, almost completely, more aggressive means of dealing with physiological types of obstruction due to nervous imbalance. A fairly large number of reports have accumulated now, attesting the great value of conservative decompression in the management of intestinal obstruction. The mortality in the group treated by suction alone has been astonishingly small. In this clinic, the case mortality in the suction group

been found that suction applied to an ordinary indwelling duodenal tube immediately before, during, and constantly after operation for a period of five days will preclude the occurrence of intestinal distension.

Another use to which the Miller Abbott tube has been placed by the roentgenologist is the identification of tumors in the small intestine. Because of the rapidity of transit of barium down the small intestine, the recognition of obstructions in the small intestine by ordinary roentgen means has been notably poor. The value of the stasis ray may be pyramided by blocking off a section of the small bowel by inflating the Miller-Abbott tube. Defects in the barium column within the bowel may then be identified more readily (Fig. 42).

Complications Involving the Tube

Knotting may occur in any tube passed into the stomach. This observation has been made, probably, in many clinics, in which an indwelling duodenal tube is used frequently. The balloon of the Miller Abbott tube has been the source of some difficulty. The injection of barium into the small channel of the double lumen tube leading to the balloon has been a source of trouble (Walker 1940) in some clinics. A more serious potential source of trouble is employing too great a pressure within the balloon, causing it to become arrested in its migration down the bowel. That protracted arrest of the balloon, in one place might injure the bowel is apparent. Periodic deflation, however, should make this an infrequent complication. Further, anyone employing the balloon-tipped tube, should orient himself well with reference to the status of inflation of the balloon at various grades of distension. The size of the balloon employed has much to do with the amount of air to be injected into it. Ordinarily, a small balloon which measures 4 to 5 centimeters in length when inflated and 3 to 3.5 centimeters in width when distended with 20 to 35 centimeters of air, gives about the right amount of contractile stimulus to the bowel wall.

In attempting to intubate the cecum in a patient in this clinic exhibiting moderate distension, the balloon became arrested, apparently at the ileocecal juncture (Smith). The balloon assumed an hourglass shape (thorotrast contrast medium employed), and that portion engaged beyond the ileocecal sphincter could not be deflated. Finally, it ruptured spontaneously, permitting withdrawal of the catheter. An erroneous diagnosis of stricture of the terminal ileum was made on the basis of the roentgen findings. Exploratory operation revealed no lesion present there, suggesting arrest of the balloon in the ileocecal sphincter as a likely explanation.

Any tube which remains long in the intestine is likely to become discolored (black). Washing the tubes frequently with warm soapy water, employing both forced injection and suction, keeps the tubes clean and the channels open and, serves also as a satisfactory deodorant.

The "Ear-Marks" of Successful Decompression

In a mechanical obstruction of the small intestine the signs of a successful decompression are (1) cessation of "gas pains," (2) decrease of

The observations are not interpreted as an indication that it is wise or desirable to pursue efforts at conservative decompression in complete adhesive obstructions in which the obstructive agent does not relent. They do indicate, however, that as long as the gut is viable, even though decompression is not achieved, that the patient's general condition remains quite the same in so far as one is permitted to judge from the pulse, temperature, and general body functions. The continued well being of the patients with severe obstruction on which suction was employed for several days before resort was had to operation has a significant bearing upon the so-called toxic factor in obstruction. The bowel wall being viable despite the presence of considerable distension no evidence of abnormal absorption occurred. This feature corroborates in a decisive manner the conclusion reached in the experimental observations, viz. that it is probably transperitoneal absorption through a bowel whose viability is impaired which determines the supervention of toxic symptoms. If abnormal absorption by the normal avenues were occurring in these patients no objective manifestation of its happening came to light.

The experiments made upon the hydrodynamics of suction applied to rigid tubes as well as the effects of suction noted in the terminal ileum upon the intra-enteric pressure of obstructed dogs and cats indicate that release of pressure at a site nearer the obstruction is in order when suction fails to influence the existing distension favorably. The observations cited above should not be construed to suggest therefore that trial with suction may be continued indefinitely. Experience dictates that in late simple obstructions, enterostomy is safer and wiser usually than release of the obstructing agent.

The Role of Conservative Decompression in the Prevention of Intestinal Obstruction

The employment of suction in the early postoperative period, after abdominal operations, eliminates almost entirely the occurrence of distension. Obstructions in the convalescent period are brought about largely by the collection of fluid and gas in a bowel whose motility is impaired. Whereas when empty such a gut may not be obstructed readily by a few fibrinous adhesions when heavy because of lack of absorption of the large quantity of fluids normally emptied into it a few fibrinous adhesions may block its continuity readily. Though no figures are available to substantiate this opinion nevertheless it is difficult to escape the impression that, the avoidance of distension in convalescence after abdominal operations will and has lessened materially the tendency to postoperative mechanical obstruction during the hospital stay. Whereas postoperative obstruction demanding operative release was not a rare event prior to the routine employment of suction to prevent distension in instances where one would anticipate its occurrence the practice of applying suction to an intubing duodenal tube appears to have done away largely with this complication. There is no reason apparent to expect however that the incidence of remote obstructions will be affected in any manner.

has been only 6 per cent. It is not to be denied, however, that there is a factor of mortality, not so readily assessed, yet, nevertheless directly attributable to overextending the indications for suction. It is to be admitted freely that suction is far more dim sighted than "blind enterostomy" in certain cases. It is highly important, therefore, that he who employs conservative decompression in the management of intestinal obstruction, school himself, not alone, in the advantages, shortcomings and weaknesses of the method, but also in the intricacies and limitations of diagnosis of acute abdominal disorders. The application of suction, as the sole direct therapeutic agent to unsuitable cases, such as strangulating obstructions, is a tragic blunder which must be avoided studiously. The results of conservative decompression will be dealt with subsequently again under the caption of The Mortality of Obstruction (See Table XXV). In most other mechanical obstructions, it is largely an auxiliary aid.

The After Story of Patients with Bowel Obstruction Treated Conservatively

The majority of the patients who have been treated by conservative decompression for obstruction have been examined or interrogated. A number have been subjected to enterolysis or to partial enterectomy because of recurrent obstruction, entangling adhesions being found usually at operation. A much larger number have remained well. This information is not startling and is in accord with the experience of enterostomy for obstruction, viz., that an adhesive band may be presumably present for years attached to the bowel without interrupting its continuity. When stasis occurs in the bowel for some reason and the small bowel becomes full of fluid, the band may kink and obstruct the gut.

Lessons Learned Concerning the So Called Toxic Factor in Simple Bowel Obstruction Attending the Employment of Suction

The frequent use of suction in the treatment of adhesive obstruction has afforded an opportunity to study the reaction of these patients. The pulse and temperature of patients with varying grades of obstruction remain normal usually during the suction period. A low grade fever is observed initially in practically every instance. This fever may come, in part, however, from the indwelling duodenal tube. It is further noted that, there is rarely a rise of pulse or temperature in any of these cases during continuance of suction therapy, including those in which resort had to be made to operation following efforts at achieving conservative reduction (Fig 34). This is particularly significant for those patients needing subsequent operation, representing in almost every case complete obstructions, which in many instances were not relieved for days. In this latter group of patients, however, it is to be noted that accompanying operation, there was always a brisk reaction in pulse and temperature which subsided slowly (Fig 38). This occurrence suggests that operation probably was deferred too long in some of these cases.

(1926) studies on the angle of inclination of the Eustachian tube explain the intolerance of the infant to the indwelling duodenal tube (Fig 43). The duodenal tube can not be left in place for long stretches of time in the infant because of its predisposition to development of otitis media. This condition has been encountered rarely in the employment of gastric siphonage in the treatment of distension, but in a series of infants, with so called congenital hypertrophic pyloric stenosis reported previously (1931) fed by the drip

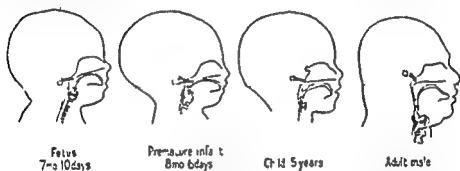


FIG 43—The angle of inclination of the Eustachian tube in the fetus, infant, child and adult (Unpublished data from Ph.D. thesis in Anatomy 1926 W. T. Peyton). The greater ease with which infection develops in the Eustachian tubes of infants and children attending use of the indwelling duodenal tube is apparent from these diagrams.

method through a small urethral catheter led into the stomach, this complication frequently developed. Were it not for this difficulty, undoubtedly a large number of infants with this condition who present themselves for treatment at the eighth to tenth week could be carried to a satisfactory termination without operation. The term stenosis is really a misnomer for there is no stenosis in the true sense—the condition being due essentially to an unusual hypertrophy of the circular sphincteric muscle of the pylorus. And it is well known that, after the fourteenth to sixteenth week, the condition clears up spontaneously not infrequently. The stomach in this condition apparently is capable of handling drip feedings over a twenty-four hour period, whereas frequent small feedings at three to four hour intervals give rise to regurgitation.

There is another complication, however, that should be mentioned, which comes occasionally after protracted use of the indwelling duodenal tube, viz. laryngeal edema. This complication has been observed a few times in this clinic. In the survey in 1938 comprising the results of the first 7 years of suction treatment of intestinal obstruction of mechanical origin, two such patients had been seen. Iglaue of Cincinnati and Molt of Indianapolis (1939) reported 12 cases, ten of which came under their supervision. The authors, however, are laryngologists and complications of this type occurring in a community would, in consequence, come to their notice. At the time of the 7 year study, in this clinic, it was estimated that more than

Lessons Learned About Vomiting

The employment of suction in the postoperative period, to obviate distension, as well as experience gained in its use in the alleviation of distension in the course of peritonitis, has thrown interesting light and evidence on the cause of vomiting in these disorders. The incidence of vomiting in a large series of postoperative cases treated by suction was strikingly diminished as contrasted with a similar group of cases in which suction was not employed. Whereas the incidence of vomiting in a series of 42 cases of peritonitis not treated by suction was 62.5 per cent, in another similar group of 43 cases treated by suction, it was 19 per cent. In another group of 15 patients with peritonitis treated with suction in which it was made certain that the tube was in the duodenum and perforations were present in the gastric as well as duodenal portion of the catheter, there was minimal vomiting in two cases.

It would appear in consequence that the most important factor in the genesis of postoperative vomiting as well as that of peritonitis is retention in the stomach and upper small intestine. The same cessation of vomiting is observed likewise in mechanical obstructions attending satisfactory decompression of the upper reaches of the gastro-intestinal tract. In such instances, however, this occurrence is not so unexpected for the vomiting is largely the evacuation of material regurgitated into the stomach from a lower level in the alimentary canal. In uremia and other states in which gastric retention is not present, the employment of duodenal suction is of no benefit in relieving nausea or vomiting.

II COMPLAINTS OF PATIENTS RELATING TO THE EMPLOYMENT OF SUCTION

About the only common complaint of patients on whom prolonged siphonage is being used is the sticking feeling or soreness of the throat caused by the tube. This is a variable factor, but most patients express some dissatisfaction over it. In some measure, the instillation of nasal oil or argyrol through the nose into the throat assuages this distress. Occasionally it has been necessary to spray the oral pharynx with cocaine solution to allay the irritation caused by the tube. In the main, however, it has been the patient who has had least need of suction who has complained most bitterly about the tube. The patient who may be inclined at first to swear at the tube, later often swears by it. In a few patients in whom a duodenal tube has been continuously in place for six weeks or longer, no objective evidence of any harmful effects, such as pressure erosion, have come to the writer's notice. Similarly, no case has been noted where ulceration of the gastric or duodenal wall has been caused by an indwelling catheter. (See below.)

It should be mentioned however that infants are intolerant of the tube being long in place because of the tendency to the development of otitis media attending prolonged suction, whether the tube is inserted through the mouth or nose. This complication has not been observed in adults or children, however, children occasionally and adults less frequently, complain of "earache" attending prolonged use of the duodenal tube. Peyton's

in Table XVIII. This table gives some indication to what extent sodium chloride has to be supplied attending use of the intlying catheter.

Coller and Maddock tabulate the approximate sodium chloride content of fluid losses from the intestinal canal as follows:

TABLE XVIII.—THE CONCENTRATION OF SODIUM CHLORIDE IN VARIOUS FLUIDS
(Coller and Maddock 1940)

	Variation in Sodium Chloride Concentration gm per liter	Average Sodium Chloride Concentration gm per liter
Vomitus	12 to 62	33
Gastroduodenal suction drainage	1.9 to 7.9	57
Hepatic bile	3.5 to 6.4	51
Intestinal fistula drainage	3.9 to 8.8	52
Diarrheal stools	37 to 52	43
Physiological saline solution		8.5 USP

Three to four thousand cubic centimeters of para oral fluids are usually adequate in amount. If the fluid aspirations, which are to be deducted from the total fluid intake, are great, more para oral fluids may be required (see page 133). It is in high obstructions particularly, that dehydration and dechlorination are likely to be prominent features requiring the more liberal administration of fluid. In the writer's experience, normal saline solution meets satisfactorily the tissue needs for fluid. As has been abundantly pointed out by a number of investigators, no other combination of the sodium or the chloride ions appears suitable. Because the body stores of glycogen from which glucose is mobilized are quickly depleted in starvation, it is a good plan to add enough glucose to the saline solution to make a 5 per cent glucose solution. As the initial dehydration is repaired by the liberal administration of saline solution and a satisfactory urine output follows, it is wise to alternate the infusion of glucose in saline solution and distilled water. The continued administration of saline solution beyond the requirement of the tissues leads to retention of sodium chloride and water in the intercellular spaces with resulting edema. The specific gravity of the urine is a valuable help in this matter (see page 133). Of the various routes in which this fluid may be given, viz., proctoclysis, subcutaneous, and intravenous, the latter is the most practical. A satisfactory manner of giving the requisite fluid is to divide the total amount fairly evenly between a morning and evening administration, giving usually 1,500 to 2,000 cubic centimeters at a time—the infusion being continued over an interval of an hour and a half to two hours each time. In this manner, the greater portion of the glucose is made available for the requirements of the body and no ill effects from too rapid administration of fluid will be apparent. When intravenous infusion is impractical because the subject is small or the veins are difficult to locate, the fluid can be given subcutaneously—probably best under the fascia lata on the external aspect of the thigh.

5,000 patients in the clinic had worn indwelling duodenal tubes for variable periods of time

A disquieting feature, however, is that in some of the patients reported by Iglauer and Molt, the complication was observed when the tube had been in place for periods of time as short as two days. The writer has the impression that fever, of a degree or more Fahrenheit, attends employment of the indwelling duodenal tube, not uncommonly. Yet, with frequent instillation of nasal oil (at least 4 times daily) into the nostrils, and, with the swallowing movements attending the drinking of water, this complication, it must be said, is by no means frequent. The experience of the past few years supports that reported previously in the 1938 survey.

Iglauer and Molt believe that the laryngeal edema results from a primary necrosis of the anterior wall of the esophagus, at its attachment to the body of the cricoid cartilage. Over the median ridge of the cricoid cartilage, the muscular coat of the esophagus is thin, and, fails to provide a good cushion between mucous membrane and cartilage. Ulceration may lead to perichondritis with subglottic stenosis and fixation of the arytenoids. Temporary tracheotomy may become compulsory in patients presenting evidences of respiratory obstruction.

G THE ADMINISTRATION OF FLUID WHILE SUCTION IS IN FORCE

The only practical and reliable measure of the amount of fluid, which it is necessary to give, is the daily urine output. Collier and Maddock, who have given this matter special study, believe that, the urine output in a 24 hour period should approximate 1,500 cubic centimeters. The writer's practice over a period of many years has been to insist on the administration of enough para oral fluid to patients who have been operated upon to insure a minimum daily urinary output in adults of 700 to 1,000 cubic centimeters. Experience has shown that this amount is also adequate and satisfactory for patients with acute intestinal obstruction. In infants and children in whom the collection of urine can not be done regularly, the requisite amount of fluid has to be determined by the wetting of diapers and more general considerations, such as the turgor of the skin. It is obvious that they require less fluid, 100 to 150 cubic centimeters per kilogram of body weight is usually adequate. The administration of fluid in excess of that mandatory to maintain a satisfactory water balance in the tissues does not appear to be desirable. It would scarcely seem necessary to utter the warning that, with the employment of suction in the treatment of stasis in the gastro intestinal canal, it is particularly important to be alert concerning tissue hydration. Failure on the part of surgeons to insist that the urine output be determined and carefully summated for every 24 hour period until convalescence has become well established is largely responsible for any difficulties on this score. The daily urine output in the early postoperative period and in all patients under observation because of acute abdominal conditions should be as carefully charted as the temperature (Fig 72). The sodium chloride losses attending drainage of various types of fluid from the intestinal canal and its appendages is indicated

in Table XVIII This table gives some indication to what extent sodium chloride has to be supplied attending use of the intlying catheter

Coller and Maddock tabulate the approximate sodium chloride content of fluid losses from the intestinal canal as follows

TABLE XVIII—THE CONCENTRATION OF SODIUM CHLORIDE IN VARIOUS FLUIDS
(Coller and Maddock 1940)

	Variation in Sodium Chloride Concentration gm per liter	Average Sodium Chloride Concentration gm per liter
Vomitus	12 to 62	33
Gastroduodenal suction drainage	19 to 79	57
Hepatic bile	35 to 64	51
Intestinal fistula drainage	30 to 55	52
Diarrheal stools	37 to 52	43
Physiological saline solution		5.8 USP

Three to four thou and cubic centimeters of para-oral fluids are usually adequate in amount If the fluid aspirations, which are to be deducted from the total fluid intake, are great, more para oral fluids may be required (see page 133) It is in high obstructions particularly, that dehydration and dechlorination are likely to be prominent features requiring the more liberal administration of fluid In the writer's experience, normal saline solution meets satisfactorily the tissue needs for fluid As has been abundantly pointed out by a number of investigators, no other combination of the sodium or the chloride ions appears suitable Because the body stores of glycogen from which glucose is mobilized are quickly depleted in starvation, it is a good plan to add enough glucose to the saline solution to make a 5 per cent glucose solution As the initial dehydration is repaired by the liberal administration of saline solution and a satisfactory urine output follows, it is wise to alternate the infusion of glucose in saline solution and distilled water The continued administration of saline solution beyond the requirement of the tissues leads to retention of sodium chloride and water in the intercellular spaces with resulting edema The specific gravity of the urine is a valuable help in this matter (see page 133) Of the various routes in which this fluid may be given, viz, proctoclysis, subcutaneous and intravenous, the latter is the most practical A satisfactory manner of giving the requisite fluid is to divide the total amount fairly evenly between a morning and evening administration, giving usually 1,500 to 2,000 cubic centimeters at a time—the infusion being continued over an interval of an hour and a half to two hours each time In this manner, the greater portion of the glucose is made available for the requirements of the body and no ill effects from too rapid administration of fluid will be apparent When intravenous infusion is impractical because the subject is small or the veins are difficult to locate, the fluid can be given subcutaneously—probably best under the fascia lata on the external aspect of the thigh

It is difficult to be certain of absorption of fluids administered by proctoclysis

The fluid permitted by mouth is usually immediately re-aspirated when siphonage is in force. In the employment of suction to prevent distension after operation, it has been the writer's practice to permit the patient a daily oral intake of 2,400 cubic centimeters of water. More, undoubtedly, could be taken without harmful effects. Unlimited oral intake of fluid, however, necessitates frequent changing of the bottles. Observation has shown also that this needless washing of the walls of the stomach results in greater loss of chlorides. In mechanical obstructions, the writer has tried both the ingestion of large quantities of water by mouth as well as total withholding of oral intake of fluid. In the main, it is his impression that a more rapid decompression is to be obtained by keeping the oral intake well within the limits specified above.

It is obvious that the fluid taken by mouth while suction is in force should be clear fluids. Apart from the consideration that fluid ingested is immediately re-aspirated, any clear fluid such as tea, ginger ale, grape juice, or strained orange juice may be permitted. On the whole, however, as long as siphonage operates continuously, water is the best fluid. When suction can be interrupted and concern exists over the adequacy of the caloric intake, lactose can be added without making a refreshing drink sickeningly sweet as would the liberal addition of sugar. Because of the clotting of milk in the stomach, it can not be taken by mouth as long as suction is necessary. Whereas, carbon dioxide is formed in rather large amounts in the digestion of carbohydrates, such gas is readily absorbed, and, in the absence of distension, no contra indication exists to their ingestion. Gaseous distension comes about more through the item of impaired intestinal motility, the nature of the food ingested is not so important as long as it can be removed, absorbed, or transported.

With employment of the Miller-Abbott tube, once it has descended well into the bowel, the patient may eat most everything and the same necessity for balancing the fluid intake by the liberal para oral administration of fluid does not obtain. Decompression, having been achieved, the aspirations of fluid from the bowel will be small in amount.

H HISTORY OF USE OF DUODENAL TUBE

Paine (1934) has traced the history of the development of the duodenal tube and its employment in the therapy of abdominal lesions. The important items recounted by Paine are listed in the accompanying table. Development of the Miller-Abbott long balloon tipped tube has occurred since Paine's paper was written.

I RECTAL SIPHONAGE

On the whole, it can be said that rectal siphonage is not satisfactory. In the main, the indication for its employment concerns cases with colonic distension, when such distension is great and is due to mechanical causes,

TABLE XX.—DEVELOPMENT OF INSTRUMENTS FOR GASTRIC AND DUODENAL INTUBATION

- 1790 John Hunter of London reported the use of stomach tube to feed a patient with paralysis of the muscles of deglutition
- 1813 Philip Syng Ihyrick reported the successful use of a urethral catheter in washing out the stomach of an infant who had ingested laudanum
- 1822 Jukes of London reported successful use of a "stomach pump" in removal of ingested poisons on dogs. He himself swallowed 10 ounces of laudanum and evacuated it with the pump without suffering harm
- 1869 Kussmaul of Heidelberg described use of the "American stomach pump" (refers probably to the stomach tube and pump constructed by Dr Wyman of Boston) in evacuating the stomach of patients with pyloric stenosis
- 1896 Hemmeter of Baltimore reported intubation of the duodenum
- 1910 Max Inhorn and Maurice Gross of New York City reported simultaneously development of simple tubes permitting duodenal intubation
- 1921 Levin of New Orleans described the smooth catheter tipped duodenal tube

Clinical Application of the Duodenal Tube

- 1910 Westermann of Germany reported treatment of 15 cases of peritonitis with gastro-intestinal stasis by continuous siphonage drainage of the stomach by means of a duodenal tube passed through the nose
- 1911 Kappis also of Germany reported 10 similar cases treated in the same manner and endorsed the method enthusiastically
- 1916 Kanavel of Chicago attached water-seal drainage to the intubing duodenal tube to enhance the efficacy of siphonage
- 1921 Matas of New Orleans advocated general use of postoperative siphonage to combat distension
- 1925 Ward of San Francisco described attachment of a water siphon apparatus attached to an intubing duodenal tube to afford a source for continuous active suction
- 1931 Wangensteen of Minneapolis described decompression of three patients with acute mechanical obstruction of the small intestine by suction applied to an intubing duodenal tube
- 1933 Paine and Wangensteen of Minneapolis demonstrated the superiority of constant suction over siphonage in evacuating the upper reaches of the gastro-intestinal tract after operation
- 1933 Wangensteen and Paine of Minneapolis reported the first series of cases in which suction had played a major role in the management of patients with acute mechanical obstruction of the small intestine (32 cases with 5 deaths a mortality of 15.6 per cent) (Twenty were treated by suction alone with 2 deaths—5 per cent mortality)
- 1934 Miller and Abbott of Philadelphia reported development of a two-way balloon tipped long duodenal tube for intubation of the small intestine
- 1938 Abbott and Johnston reported decompression of instances of mechanical obstruction with use of the long Miller Abbott tube

a direct operative attack on the colon is indicated, in those instances of ileus due to peritonitis, where the colon participates in a general distension irrigation of the colon is contra indicated. There is undoubtedly a limited group of cases in which the method of rectal siphonage employed by Pratt is of value, viz, suction alternated with fluid injections employing a small inlet catheter and a large outlet tube. The sigmoid and splenic flexures of the colon in addition to the feces afford obstacles to invariable success with the method. In carcinomas of the rectal ampulla causing obstruction, decompression can be effected occasionally by passing a catheter through a proctoscope beyond the point of obstruction.

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CHAPTER VII

OPERATION IN BOWEL OBSTRUCTIONS

A SURGERY THE MAINSTAY OF THERAPY

SINCE the advent of anesthesia and the birth of aseptic surgery, operation has been the chief remedial agent in dealing with bowel obstruction. It remains still the mainstay of therapeutic measures in the therapy of obstruction. Despite improvements in the technique of all surgery, the results of operation for bowel obstruction have shown no such betterment. Yet, the results of early operation, on the whole, have been in accord with those obtained in dealing with other acute abdominal lesions.

The penalty of late recognition of bowel obstruction is apparent in every statistical study of the subject. Yet, whereas ten or twelve hours delay between the occurrence of perforation of a duodenal ulcer and its closure begins to have an ominous significance, whether in the hands of the average or the most expert and facile surgeon, a much wider latitude is accorded the patient with bowel obstruction in both time and matters of circumstance. A patient with an acute adhesive obstruction of simple nature of 48-72 or more hours' duration has a good chance of recovery with well-executed surgery. Whereas the time element is probably the most significant item in the determination of the issue in the surgical treatment of a perforated duodenal ulcer, the choice of operative procedure and the kind of surgery practiced in the relief of late bowel obstruction are all important. Early in the course of obstruction, the experience of the surgeon does not affect the nature of the outcome so decidedly. Late in the obstruction, all depends on the manner of release of the obstructing mechanism. Late perforations of duodenal ulcers are doomed usually by the time element alone and the skill of the surgeon matters but little.

Selection of Cases for Operation

With the single exception of reduction of intussusception by conservative means, operation until recently has been the only remedial agent of value in treating patients with bowel obstruction. Operation still is, and probably will continue to be, the chief mainstay of therapy in most forms of bowel obstruction. It is, however, apparent that some cases need not be operated upon, particularly patients with partial simple obstruction of the small intestine. The accompanying diagram indicates in general terms the treatment indicated in the various clinical varieties of obstruction (Table XX).

The classes of cases which demand urgent operation are (1) instances of strangulating obstruction and (2) acute obstruction of the colon with great distension. All patients with simple obstruction in which the nature of the occlusion is known to be such that operative relief will be necessary,

should be subjected to early surgery. Among this group are the congenital intestinal atresias of the new born and imperforation of the rectum and anus, conditions which are usually readily identified. Strictures of the small intestine, which usually give rise to a picture which identifies the disaster, usually can be treated satisfactorily by suction and operated upon in an unobstructive phase. Physiologic obstructions, viz., spastic and

TABLE XX.—CLASSIFICATION AND TREATMENT OF INTESTINAL OBSTRUCTIONS
(The consideration of special obstructions in Part IV will follow this outline.)

Clinical Classification	Pathologic Classification	Treatment
I Mechanical A Narrowing of lumen 1 Strictures of bowel wall a Congenital { Atresia Imperforate anus Inflammatory b Acquired { Traumatic Vascular Neoplastic 2 Obturation 3 Compression from without (especially pelvis and retroperitoneal duodenum)	Simple except in neoplastic strictures of the colon	Operation preceded by suction for decompression in late cases except in occlusion of the colon
B Adhesive bands { Congenital Inflammatory Traumatic Neoplastic	Simple or strangulation	Suction operation for persistent obstruction and in strangulation
C Hernia 1 External 2 Internal D Volvulus E Intussusception F Errors in development of the intestine giving rise to intestinal obstruction	Strangulation	Early operation
II Nervous (physiological imbalance) A Inhibition (ileus—paralytic) adynamic B Spastic ileus—dynamic	Simple	Suction
III Vascular Thrombosis and embolism of mesenteric vessels	Strangulation	Early operation

inhibitive (paralytic) ileus need operation rarely. Occasionally, the former, when the distension concerns the colon, can not be distinguished from mechanical obstruction of the colon. On more than one occasion the writer has operated upon a patient with spastic obstruction of the colon with enormous distension under the impression that the lesion was probably an obstructing malignancy in the pelvic colon. To treat a patient, with enormous colonic distension due to organic obstruction of the pelvic colon, conservatively as a case of spastic ileus would be disastrous. All acute

mechanical obstructions which do not respond favorably to a period of trial with suction should be operated upon

General Considerations in the Selection of Operative Procedure

The chief factors which influence the choice of procedure in dealing with bowel obstruction are these (1) Is the obstruction early or late? (2) Is it simple or strangulating in character? In simple obstructions, the time element figures prominently in the decision as to what should be done. Strangulating obstructions, on the contrary, permit of no alternatives in the choice of procedure except as indicated by the condition of the bowel. In any event the imprisoned gut must be released from its constriction and the viability of the gut determined. If non viable, it must be excised, if the integrity of the gut wall is maintained mere release of the bowel suffices usually. In instances where uncertainty prevails as to the viability of the gut the procedure depends largely upon the gravity of the doubt entertained concerning the chances of survival of the bowel wall, if slight a proximal enterostomy is in order, if great, the bowel in question should be exteriorized or preferably excised.

The latency of the obstruction and its nature can be determined largely by clinical and x ray evidence. Whether an obstruction is late or early is not wholly a matter of time. A partial obstruction of a week's standing may not be as advanced as one which is of only 48 hours duration but complete. Yet, patients may die of a partial obstruction. The degree of distension as revealed on an x ray film, together with the patient's general condition, determines largely whether an obstruction is late or early.

Similarly a simple or strangulating obstruction may be differentiated with considerable, though by no means absolute, accuracy by the diagnostic criteria described previously. If any doubt remains the opening of the abdomen serves to distinguish. A strangulating obstruction is heralded by a bloody peritoneal fluid and an infarcted gut. Hemorrhagic peritoneal fluid is observed so rarely in simple obstruction that its mere presence is indication that search should be made for strangulated bowel. The time element figures prominently in the determination of the procedure in most cases of strangulating obstruction. The only obstruction of this variety in which vessels are actually blocked is mesenteric thrombosis or embolism, all other strangulating obstructions may be regarded as simple in nature if the influence of the agent compromising the blood supply is removed early.

II CHOICE OF OPERATIVE PROCEDURE

The available operative procedures from which the surgeon has to choose in relieving obstructions, apart from special methods described under the caption of individual obstructions, are (1) division of adhesions and release of the bowel from an entangling or compressing agent, (2) enterostomy, (3) exteriorization of the bowel with the establishment of a complete external fistula, (4) the making of an entero anastomosis around the obstructing mechanism, and (5) excision of the obstructed

segment of bowel and the establishment of continuity by primary anastomosis

The outcome in bowel obstruction is determined as much by the operative procedure chosen by the surgeon as by the manner of its execution. In part, the choice of operation is already decided for him by the type of obstruction present. In strangulating obstructions, save in most unusual circumstances, whether the bowel is viable must be definitely ascertained, release from the strangulating mechanism must be obtained and, if the bowel is not viable, it must be excised. The only choice granted the surgeon is whether he will exteriorize the devitalized bowel and establish a temporary complete external fistula or re-establish its continuity by primary anastomosis. Alternative procedures manifestly are not applicable in such instances as may be invoked when the continuity of the gut alone is obstructed without interference with its blood supply. There may be occasions when it is wiser to decompress the bowel proximally by enterostomy and to leave the strangulated segment, obviously, however, this procedure could only be effective in those instances in which the bowel involved actually is viable, and when reduction of intra-enteric pressure in the bowel proximal to the incarceration can affect favorably the blood supply of the strangulated loop. In intussusception, when it is evident that a portion of the intussusception is non-reducible or non-viable, the employment of enterostomy is fully justified occasionally, because the intestinal segment with compromised blood supply lies within a normal ensheathing cylinder, furthermore, the only obstruction to intestinal continuity is constituted by the compression of swelling and edema, proximal enterostomy in such an instance may permit of automatic restitution of interrupted intestinal continuity. Obviously there still is much left to chance: (1) the possibility of hemorrhage with sloughing of the telescoped bowel and (2) the necessity for re-operation. To be certain, these are not so serious, and if such a compromise measure appears to be the wisest expedient, it still holds out a reasonable chance of success. When this same procedure is applied to a strangulated segment lying within the peritoneal cavity unprotected by an ensheathing cylinder of normal bowel, it is evident that unless the imprisoned bowel can maintain its blood supply, this instrument is doomed to fail. An operative procedure must have a reasonable chance of a favorable termination. The one which affords the patient the greatest promise with the least risk should be selected always. If at all feasible, the writer prefers primary resection, employing the closed anastomosis, to the compromise measure just described.

In simple obstructions, particularly where a choice of procedure may often be made, it is of the utmost importance that the surgeon choose wisely. The essential requisite for a successful issue is that the operation which relieves the distension or restores simultaneously intestinal continuity must be done *aseptically*. The great significance of this factor for the safety of the patient can not be overemphasized. Another important consideration is that the procedure of least magnitude is most easily withstood by the patient. It is well known that patients with acute bowel

obstruction tolerate extensive manipulation of the bowel poorly. Just wherein the danger to the patient lies is not exactly known. That this hazard menaces recovery is apparent in the operative mortalities of those surgeons who favor and insist upon removing the obstructing agent or releasing the gut from its influence wherever possible. The surgeon naturally feels more at ease over the eventual result when he has left little to chance by the direct operation of election. He who has weighed carefully the great gain which is to be had by draining the distended bowel in simple obstruction knows how favorably chance inclines to a promising outcome attending employment of decompressive types of operation. Immediate evacuation of the bowel by stripping out its content is not necessary in the lesser obstructions and may be a perilous expedient in the late ones. Despite the successes which have been achieved by its employment in the hands of experienced surgeons it is not a method to be recommended for general use. Moreover an aseptic decompressive enterotomy will be described below under Caption Q directed at evacuation of the distended bowel at operation, without the hazards attending employment of the Monks Moynihan stripping procedure.

Much has been written concerning the role of anaerobic infection and the toxins of the Welch bacillus in bowel obstruction. The experience of the writer leads him to believe that there is not much to be feared from this agency as long as the bowel is viable and no peritoneal contamination has occurred.

Simple Obstruction

In early cases, the operation of election may well be done, that is, the exact site and nature of the obstruction may be sought out. When the obstructing agent is extrinsic to the gut wall, the gut is to be freed from it. When an intraluminal obstruction, such as a gallstone or an intrinsic obstruction in the gut wall as a stricture, are present the exact mode of dealing with the occlusion is not so obvious. All wide openings or anastomotic procedures on the gut are to be avoided wherever possible because of the risk of peritonitis. The gallstone may occasionally be pushed back from its site of incarceration to a higher level and crushed. If the gut is opened for its removal, great care is to be observed to avoid spillage. An aseptic enterotomy for removal of an obstructing gallstone is described in Chapter XIV. In the instance of benign strictures in the gut wall enterostomy followed by excision in a non obstructive phase is probably the wisest choice of procedure. In malignant strictures of the small intestine, especially when low in the ileum, preliminary exteriorization as is done with infarcted bowel followed by secondary anastomosis is the procedure of election. In the presence of malignant strictures high in the jejunum, a primary aseptic entero anastomosis about the lesion followed by its excision in a non obstructed phase probably carries least risk for the patient. Fortunately, in many acute obstructions of this type, decompression can be accomplished by suction applied to an indwelling duodenal tube.

The judicious choice of operation in late cases of simple obstruction will do more to lower materially the operative mortality of bowel obstruction than any other group of factors. Decompression by enterostomy or colostomy, depending upon whether the small intestine or colon is obstructed, is the operation of choice. In late simple obstructions many lives are sacrificed because of the anxiety of the surgeon to do a complete operation. This is particularly notable in instances of complete adhesive obstruction of several days standing. In such instances, adhesive bands have become fused virtually with the gut wall. Detachment or release of the adhesive bands results frequently in opening the gut with escape of its highly infectious content into the peritoneal cavity. Anything, which the surgeon might then do, cannot favorably influence the situation. The patient is thrown upon his own resources which are almost consistently inadequate to enable him to cope successfully with the peritonitis which follows invariably. To be certain, recovery has attended spillage from the intestine by the surgeon in operating upon a distended and obstructed bowel in this clinic. Far more frequently, however, such contamination in the presence of obstruction presages an unhappy ending.

The effect of a band upon the gut was studied in a number of dogs and rabbits by passing a suture or the tape ligature in the manner of a U around the ileum. In turn it was brought out through the abdomen, threaded through two eyes of a button, and tied on the anterior abdominal wall. Such a ligature may cut through in four to six days, depending on how tightly it is tied. The gut wall above the site of occlusion though dilated had firm texture; that beneath the tie was thin and extremely friable, indicating the hazard of manipulating it. Whereas frequent perforation of a loop so obstructed did not occur spontaneously, slight traction exerted upon it frequently caused rupture and leakage. The reason that contamination, from spillage from the obstructed intestine, is so much more hazardous than from the normal, is because of the well known tremendous increase in bacteria in the fluid content of the obstructed bowel.

It is the conviction of the writer from his own experience in performing enterostomy for late simple obstruction that, provided the gut can be tapped aseptically without the slightest trace of spillage, the patient gets well usually, no matter how distended the bowel or how ill the patient is. One hears it said not uncommonly or finds it related that the gut was dilated to the extent that its wall had become paralyzed and in consequence enterostomy was a failure. Undoubtedly there is an optimal grade of stretch for the muscle of the gut at which its contractile activity works to the best advantage, obviously this is not a fully collapsed gut, neither is it one dilated to its utmost capacity. All smooth muscle, moreover, possesses a great capacity for accommodating itself to varying grades of distension, as has been pointed out previously, unless the circular muscle of the gut is torn one would expect it to contract down. Actually this is what happens invariably, when one isolates a tremendously distended segment of bowel between two rubber covered intestinal clamps, as soon as the content of the very much thinned out

gut is aspirated, the bowel wall collapses immediately, and in a few seconds the gut wall becomes also considerably thicker owing to the contraction of its circular muscle.

In late simple obstructions with considerable distension, therefore, failures with enterostomies are not because of the inadequacy of the method but rather because the usual enterostomy is not done aseptically. Van Beuren and Smith (1927) state that there is as much chance to improve the patient with ileus by enterostomy as there is to cure a patient with fatal chemical poisoning by the same means when the poison has been absorbed. Certainly, this statement is in uncompromising conflict with what we know about the effects of obstruction as well as with experience in the performance of enterostomy. The mortality of enterostomy in late cases of simple obstruction in which the bowel is viable should not be 70 (Scudder Zwemer and Whipple 1938) 77.7 or 90.9 per cent (Van Beuren and Van Beuren and Smith 1920, 1927). When aseptic enterostomies are done the mortality will approach zero in direct proportion to the success with which the technique is carried out aseptically. Despite the fact that enterostomy will always be done upon the worst cases of simple obstruction upon which one does not dare to do any other procedure if the gut is viable, the mortality should be low.

To be sure in a few instances an enterostomy may have to be followed by a subsequent direct attack upon the obstructing mechanism even in adhesive obstructions. When the bowel has been decompressed by external drainage and when the gut wall will not be opened so easily inadvertently, as it is in an obstruction of three or four days standing a second operative attack may be contemplated by the surgeon with far greater equanimity, if found necessary.

C PRE-OPERATIVE PREPARATION

It is extremely important to know whether the patient is a good risk for operation. This determination rests essentially upon an evaluation of the patient's general physical condition. Dehydration and dechlorination, common accompaniments of obstruction of the small bowel, owing to repeated vomiting, must be combatted with adequate replacement of water and electrolytes (sodium chloride). The fluid requirements of obstructed patients are discussed at length in the chapter on pre- and post-operative treatment. Inasmuch as the time factor is of importance in preparing an obstructed patient for operation the intravenous route of infusion of saline solution constitutes the method which accomplishes the objective most quickly. Obstructed patients who have had considerable vomiting present usually evidences of hemoconcentration and are, as a rule oliguric. In addition, the suggestions of Collier and Associates (1938), with reference to the salt deficit estimated from the plasma chlorides are to be kept in mind, in the administration of saline solution to dechlorinated patients (p. 132).

If the obstruction is believed to be strangulating in character, and the pulse is hurried and the blood pressure is hovering around potential

shock levels (100 mm Hg or less), transfusion of blood or plasma is mandatory before operation is undertaken. More and more, surgeons have been becoming increasingly alert to the great importance of combating blood loss adequately. To operate upon a patient with volvulus or intussusception or other variety of strangulating obstruction, without meeting adequately, preoperatively, the loss of blood occasioned by the strangulation, invites disaster and is foolhardy. Only the planned procedure, which meets all the known exigencies of the situation, affords promise of success. The difference between success and failure is often only a hair's breadth, but the difference between a live man and a dead one is real.

It is important to know that the stomach is empty. Suction, applied to an inlying duodenal tube, plays such an important role in the management of obstruction that, no patients are sent to the operating room without the catheter being fastened in place. It is a good plan to have suction in force during operation to avoid vomiting and regurgitation of vomitus into the lungs, the most frequent cause of postoperative pneumonia. A set of suction bottles, as employed in the decompression of patients with bowel obstruction should be in every operating theater. In infants and children, in whom the urinary bladder is practically an intraperitoneal organ, it is important to be certain that it is empty—particularly when fluid has been given liberally preoperatively.

In brief, the state of hydration of the patient, the status of the circulation, the condition of the stomach and the urinary bladder are the items which demand particular attention before operation. If an hour or more is to intervene between admittance to hospital and operation, it is well to prepare the skin of the patient's abdomen in the ward. Washing and shaving consume time and should be done with care. Gentle sponging of the skin with benzine and ether dissolves the grease and permits more effectual action of the antiseptic later to be applied before operation. As a final step in the preliminary preparation of the skin on the wards, it is well to apply a sterile dressing, a small quantity of alcohol being poured upon the undermost layer of gauze. Every caution is to be observed, not only to preserve as absolute an asepsis as possible during the performance of the operative procedure, but every detail relating to the operation must be scrutinized from the standpoint of meeting the inflexible demands of rigid asepsis and antisepsis. A very important consideration is the adequate masking of active participants in the operation as well as spectators. Everyone should wear a mask covering nose as well as mouth. Bacteria are too dangerous to warrant anyone assuming unnecessary peril for the patient by failing to observe precautions which are known to protect him. Thoughtful preparation for operation, intelligent and precise execution of procedures which maintain sterility of the peritoneum, and watchful postoperative treatment constitute the best assurance for recovery from operation for bowel obstruction.

Novak's solution has been employed to afford skin antisepsis as a substitute for iodine in this clinic for several years. The formula appears in the accompanying table.

TABLE XXI—FORMULA FOR NOVAK'S SOLUTION FOR PREPARATION OF SKIN
PRIOR TO OPERATION

(Novak and Hall 1939)

Alcohol	525 cc
Acetone	100 cc
Water	375 cc
Tricresol	5 cc
Mercuric chloride	0.7 gm
Forn 1	0.6 gm
Acid fuchsin	0.8 gm

DISSECTION OF ANESTHETIC

The ever present possibility that regurgitation might occur during the administration of inhalation anesthesia, despite pre-operative evacuation of the stomach made it almost mandatory that some other type of anesthesia be employed in the surgical relief of bowel obstruction. The application of constant suction to an intubing duodenal tube before and during operation has changed all this. If the patient is a satisfactory risk from the general standpoint, no contra indication to the use of inhalation anesthesia obtains.

Spinal anesthesia is ideal because the relaxation afforded permits the surgeon to work with the greatest facility. Despite this advantage of spinal anesthesia the writer is inclined to favor the employment of ethylene or cyclopropane reinforced by whatever amount of ether is necessary to

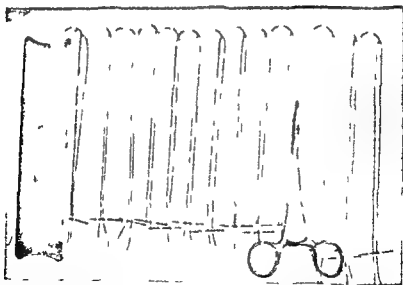


FIG 44—Intestinal suture pack. Fine silk sutures mounted on small curved needles. The shorter sutures are 15 cms in length and the longer ones are 40 cms (15 and 16 inches). The shorter are employed largely for the making of anastomoses. About a dozen of each are mounted on needles before the operation begins. Use of three such small needle holders shown here permit placement of sutures with despatch.

obtain adequate relaxation. A wide experience with this combination of anesthetic agents in a number of diverse conditions has convinced the writer that inhalation anesthesia administered skillfully, provides the greatest safety for the patient. Advanced age does not constitute a legitimate exception. The usual practice of this clinic, under the supervision of Dr. Ralph Knight, Director of the Division of Anesthesia, is to induce anesthesia by the intravenous injection of pentothal sodium, a Magill intratracheal tube is then passed and adequate relaxation can be maintained by the administration of cyclopropane. As small a dose of novocain as 100 milligrams injected into the subarachnoid space of the lumbar region has brought about fatal asphyxia, despite the use of all well known adjuvant measures to combat the dyspnoea. It is particularly in the bad risk patient, where one would like to use spinal anesthesia that it appears to be most hazardous, in the satisfactory operative risk, spinal anesthesia may be employed with greater equanimity. Until means are available of securing adequate anesthesia with safe doses, the advantages of spinal anesthesia will have to be put aside in favor of the increased safety and controllability of inhalation anesthesia. In recent years, however, surgeons appear to have had more success and fewer unhappy experiences with spinal anesthesia. This writer has continued nevertheless, to employ inhalation anesthesia. Graham and Brown (1939) have stated, "a surgeon who operates upon a patient suffering with acute intestinal obstruction using inhalation anesthesia, if adequate facilities for spinal anesthesia are available, is guilty of malpractice." The practice of this clinic with inhalation anesthesia in the surgical management of acute intestinal obstruction does not substantiate this contention of Graham and Brown.

An operation, such as enterostomy, can be done readily with infiltration of the field of operation with novocaine. Some of the newer intravenous anesthetic agents, such as pentothal, are very satisfactory for short operations, but the writer has had no experience with their use in major abdominal surgery. The choice of pre-operative medication is related intimately to the choice of anesthetic agent. Morphine is to be used with great caution at the extremes of life. In infants and children and in patients over seventy years, because of the hazard of depressing respiration, morphine is to be avoided. For the years between, the usual hypodermic administration of atropine sulphate (gr 1/150 or 0.4 mg) and morphine sulphate (gr 1/6 to 1/4, 10 to 15 mg) are satisfactory. The pre-operative administration of barbiturates, such as sodium amytal, may diminish the amount of anesthetic required. Such preliminary medication, together with morphine and infiltration of the operative field with novocaine, frequently make it possible to omit the use of ether. In a patient who is otherwise a good risk, however, ether is a safe anesthetic.

It is well known, to be certain that ether lowers the threshold of sensitivity to histamine. Unless considerable manipulation of the bowel is contemplated, however, this factor in bowel obstruction is of no great concern, for there is no proof of abnormal absorption of histamine from the bowel lumen when its wall is viable. Sperling and Kremen, however, noted that obstructed dogs tolerated the ill effects of "stripping" of the gut

better under anæstheia with barbitalurates than under ether. This same protective influence of barbitalurates against strychnine poisoning is well known and has already been referred to.

3. CONDUCT OF THE OPERATION

Before operation is undertaken everything necessary for the safe and expeditious conduct of the procedure should be in readiness. Needles should be threaded with fine sutures that are immediately available. All details of the operation are to be arranged beforehand. The patient must be kept warm and loss of body heat guarded against during the operative procedure. The blood pressure must be followed carefully by the anæsthetist throughout. It is a good plan to see to it that the legs of the patient are 6 to 10 inches (15 to 25 cm.) above heart level. This precaution guards against segregation of blood in the lower extremities during operation.

It is to be remembered that whereas a patient with bowel obstruction does not present usually the distinguishing characters of shock, viz., a depressed arterial blood pressure and a rapid pulse, yet the dehydration incident to vomiting makes him more susceptible to operative shock. It is wise, therefore, to look upon such a patient as being in potential shock and to treat him accordingly. In placing the patient on the table it is always well to expose an extremity properly so that an intravenous infusion may be started on a moment's notice. The practice in this clinic is to start an intravenous infusion when the patient is draped for operation, a leg vein usually being chosen for the purpose. If the illness has been long enough to be reflected in the patient's general status even though saline solution has been generously administered pre-operatively and the blood pressure is normal it is a good plan to give 300 to 1000 cubic centimeters of plasma solution during the operation. It serves as an antidote against shock. Should depression of the arterial pressure below 100 millimeters of mercury occur despite the infusion of plasma transfusion of blood is in order.

The length of the operative procedure is not as important as the care with which it is executed. In the ledger of failures and successes nevertheless, it is still a significant item and particularly in the late cases. Yet hurry on the part of the surgeon must be discouraged. If the patient has been prepared properly for operation the necessity for hurry becomes less urgent.

The Incision

The location of the incision will be determined wholly by the type of operative procedure contemplated. If the operation is somewhat in the nature of an exploratory operation a mid line subumbilical or a mid right rectus incision is usually best. Most instances of small bowel obstruction can be approached satisfactorily through such an opening. When operating upon children it is well because of the extrapelvic position of the urinary bladder, to make the incision somewhat higher. In instances of small bowel obstruction, when it is quite clear that enterostomy is the operation of

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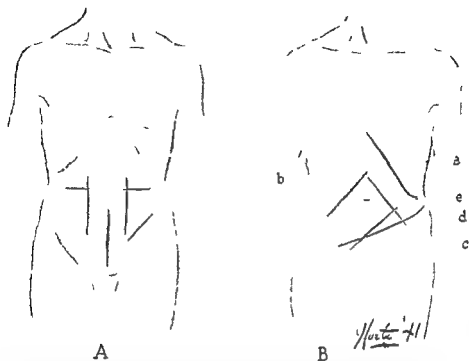


FIG 45—Abdominal incisions for operations upon the gastro-intestinal canal. A Incisions employed in this Clinic for operations in the presence of acute intestinal obstruction. Incisions should not be made in the immediate vicinity of a previous scar lest a distended adherent loop of bowel be opened on entering the abdomen. Because many operative procedures for acute intestinal obstruction are in the nature of an exploratory operation the vertical incision is usually the approach of choice. The transverse incisions are employed for decompressing the obstructed colon (see Fig 51). The left oblique incision is reserved for the occasional decompression made for acute obstruction. When it is known that the distal lying lesion is operable ceco-tomy for acute colonic obstruction is never performed in this Clinic. B Incisions for operations of election in the gastro-intestinal canal. (a) left subcostal incision for gastric resection including total gastrectomy. This incision affords superb exposure. In the closure of the blind end of the duodenum it is to be remembered that the first portion of the duodenum is practically a midline structure. (b) Incision employed by the writer for excision of the right half of the colon. This incision is superior to a right or left Hoag incision shown in D in that it permits ready access to the transverse colon in the making of the anastomosis. (c) incision suitable for excision of a lesion in the sigmoid flexure. B or C suffice for resections of the small intestine. (d) The Hoag incision—a physiologic incision with respect to preservation of nerve and blood supply useful in excision of the pelvic colon. (e) Incision for lesions of the splenic flexure or descending colon. The latter lesion demands mobilization of pelvic and splenic flexures. This incision in the writer's experience affords excellent exposure. The vertical incision is avoided studiously in all operations of election (see text).

choice, a short oblique incision over the left rectus muscle pulling the latter medially, constitutes a very satisfactory approach (Ravdin). The level of the incision with regard to the vertical spread of the muscle is to

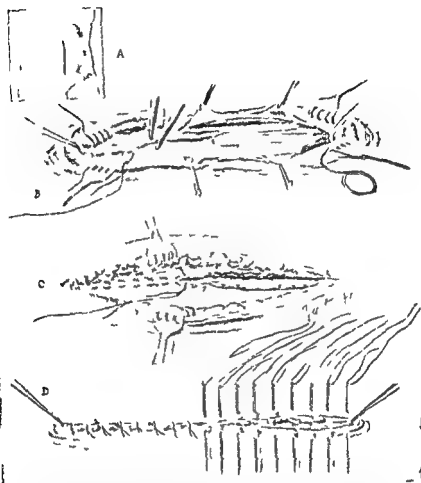


FIG 46—Closure of an abdominal incision A The incision B Closure of the peritoneum The McNealy viscera retainer is in place If the peritoneum and posterior rectus sheath do not come together easily the sutures should not be tied till all have been placed Traction on the sutures will then permit ready approximation usually C Closure of the anterior rectus sheath In the peritoneal closure employment of the Halsted mattress suture affords nice peritoneal approximation In the anterior fascial suture the angle stitch is probably to be preferred to the Halsted suture shown here in that less silk is buried Interrupted silk sutures are employed throughout the closure Silk sutures possessing a 5 to 8 pound test strength are large enough Sutures need not be stronger than the tissues they approximate No retention sutures are necessary D The skin closure

be determined by inspection of the scout x ray film of the abdomen Obstruction of the lower reaches of the small bowel calls for a low incision, in which event it is best to make a vertical incision on either side of the linea alba In the absence of obstruction, the vertical incision has come to be regarded in this clinic, more and more, as unphysiologic—which, of

course, it is, inasmuch as the lateral pull of the oblique muscles of the abdominal wall is tending to pull the incision apart. However, in the presence of distension, the paramount consideration is exposure, especially if the obstructive mechanism is to be sought out and liberated. Hence, oblique or transverse incisions are not as useful, in the presence of great distension, as when distension is absent.

When the obstruction is in the pelvic colon, the most satisfactory approach in the writer's experience, has been to place the incision directly over the transverse colon. If it is a reasonable presumption that the lesion is carcinoma, which will necessitate further operative attack after the relief of the acute obstruction, a short transverse incision over the course of the transverse colon immediately to the right of the mid line is best, if, however, the operation is also somewhat in the nature of an exploration upon the pelvic colon, it is better to place the incision to the left of the mid-line. The course of the transverse colon, as seen in a pre operative film made with a small opaque object fastened over the umbilicus, affords an excellent guide for the location of the incision through which the colon may readily present itself (Fig 50, p 199).

F LOCATING THE OBSTRUCTION

It is not always necessary to find the obstruction. In the absence of a strangulating variety of obstruction, the most important consideration of operation is to relieve the distension and preserve the viability of the bowel wall. The clinical picture when interpreted in the light of the x ray findings affords a means of identifying correctly the majority of obstructions before operation. Strangulating obstructions must always be sought out; their presence is heralded at operation by sanguineous peritoneal fluid.

When an incision has been made that is somewhat in the nature of an exploration it is always wisest to first hold up the abdominal wall with retractors and look inside. In disregarding this simplest of procedures, the obstruction may not be located without diligent and prolonged search with the hand in the abdomen. Short of a routine "going over" of the entire intestine, it is the most efficient method by which to locate an obstruction in the small intestine. The most distal portion of the colon which appears distended on the x ray film is the site to examine for obstruction in the large bowel.

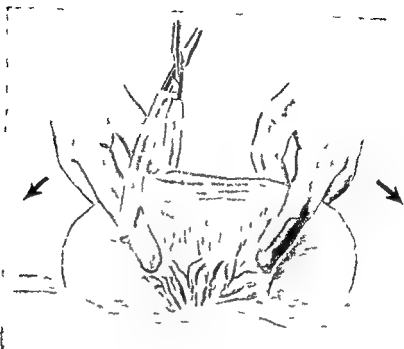
Many years ago Greig Smith pointed out that a distended intestinal coil in the proximity of the occlusion of the small bowel will usually present itself into the wound. If the point of obstruction does not come within range of direct vision, pursuit of the coil in the direction that presents itself least readily will usually lead to the obstruction. The bowel proximal to the obstruction is hyperemic as well as dilated, small bowel beyond the obstruction is collapsed. When the obstruction does not immediately present itself and it would appear wise to ferret it out care should be observed to obviate evisceration. With recognition of the value of the x ray film, when properly correlated with the clinical findings, in

affording orientation concerning the site of the obstruction, the old guide of first determining at operation whether the cecum is empty or distended is rarely of help. Finding the obstruction in the small intestine when evidence points toward its being met with in the colon, or vice versa, should be a most unusual occurrence. The descriptions of Monks, relating to fat deposition in the mesentery and the character of the arterial arcades, afford the surgeon helpful aids in orienting himself, with reference to the segment of small bowel concerned. Similarly, the suggestions of Wilms to determine the level of the mesenteric attachment has some value in orienting the surgeon concerning the site of obstruction.

G ENTEROSTOMY

"Blind enterostomy has a wide field of usefulness in the treatment of mechanical obstructions of the small intestine. There are those, however, who would abandon the operation altogether in favor of the more direct procedure of releasing the obstruction. This writer cannot accept that view. The time has come to speak of the mortality of the operation as well as of the disease. He who arbitrarily looks upon the direct operation of election as being the operation of choice in most cases and rejects the compromise measures of drainage of the bowel accepts many unwarranted risks for his patients. To be certain where an obstructing agency can be simply dealt with by the severance of an adhesive band which comes readily into view it should be done. But the determination to find and release every obstructing mechanism and to restore intestinal continuity is an ideal objective but an unwise policy. In cases of adhesive obstruction of several days' standing deliberate pursuit and division of adhesive bands is particularly likely to lead the surgeon into difficulty. In the local reactions incident to distension such bands may become practically fused with the gut wall, such that separating or cutting them may result in opening the bowel, which unfortunate event almost invariably portends a fatal outcome. The temptation to free the bowel from such bands may be great but if not prudently resisted, the surgeon may find like Pandora that opening of the box caused Evil to escape and only Hope remained, a most unreliable refuge in such instances.

In order to be successful enterostomy must be well performed and without visible trace of soiling. A valvular enterostomy with subsidence of the obstruction will close spontaneously on withdrawal of the catheter and even minimal temporary external drainage should be a rarity. A deliberate high enterostomy as advised by Bonney and others is to be avoided; it is better to place the drainage vent nearer the obstruction. However as has already been pointed out (p 140) the amount of drainage through an enterostomy correlates directly with the grade of obstruction; the level in the bowel at which the enterostomy was done does not determine the escape through the catheter. A high enterostomy is not much more likely to succeed in effecting decompression than an indwelling duodenal tube.



A



B

FIG 47—Operative decompression of distended small bowel to avoid spillage

A—Method of emptying a distended loop of small bowel preparatory to enterostomy. It is well to aspirate with a needle following the application of clamps to make certain that the loop is empty.

B—Alternate mode of emptying a distended loop of small intestine which can not be delivered and evacuated by the stripping process shown in Fig 47A. The simple instrumentarium for this procedure should be available at every operation for acute intestinal obstruction.

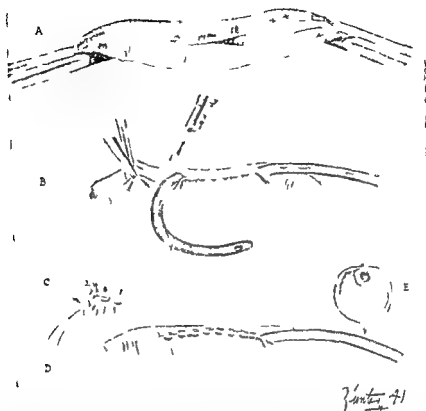
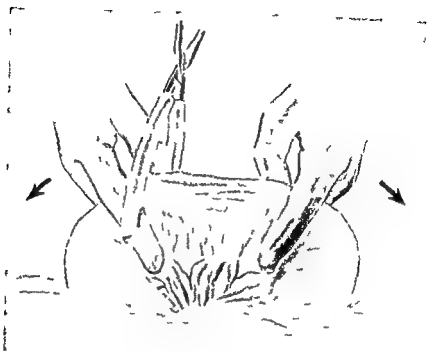


FIG 48—Technique of enterostomy. A Contraction of a distended bowel upon evacuation of its content. This occurs immediately and the bowel wall thickens surprisingly. B A number 14 French catheter is laid upon the bowel and a few interrupted Halsted mattress sutures of fine silk makes a tunnel for the catheter. Care must be taken to avoid spillage in puncturing the bowel. The catheter is then anchored with a catgut suture to the bowel wall as indicated in Fig 50. C Employment of the 3/2 stitch to close the corner after introduction of the catheter into the bowel. D Completion of the inversion. E The resultant peritoneal tunnel. With drawal of the catheter when enterostomy is made in this manner is not followed by fistula.

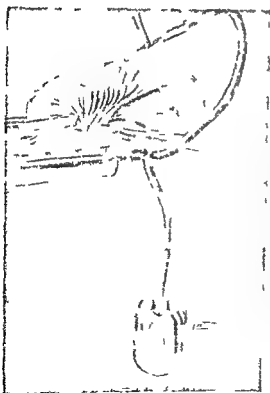
The Technique of Enterostomy

The site—Any distended loop of bowel proximal to the obstruction may be selected for the site of drainage. On the whole, the nearer the site of the obstruction the more adequate will be the decompression. The amount of gas as well as fluid drainage, however, is dependent largely upon the grade of the obstruction. When, following decompression the nature of the obstruction is such that automatic re-establishment of the continuity of the gut occurs as in most complete adhesive obstructions (even when no direct attack is made upon the obstructive agency), there

INTESTINAL OBSTRUCTIONS



A



B

FIG 47—Operative decompression of distended small bowel to avoid spillage

A—Method of emptying a distended loop of small bowel preparatory to enterotomy. It is well to aspirate with a needle following the application of clamps to make certain that the loop is empty.

B—Alternate mode of emptying a distended loop of small intestine which can not be delivered and evacuated by the stripping process shown in Fig 47A. The simple instrument for this procedure should be available at every operation for acute intestinal obstruction.

will be no considerable prolonged escape of either gas or fluid. These are contingent upon the degree of obstruction and not upon the level in the gut, at which the decompression is made. Still it is obvious that the nearer the enterotomy is to the site of obstruction the more complete will be the evacuation of the gut immediately above the obstruction, with consequent earlier restoration of its continuity. Hence on the whole jejunostomies drain more freely than ileostomies but only because re-establishment of intestinal continuity does not follow so readily.

Tapping the bowel aseptically—The only manner in which one may safely place sutures in a very thin and distended bowel is by emptying it so that its muscle will contract and lend substance and thickness to the gut wall. By segregating a segment of gut between two clamps first "milking out" some of its content by running this segment through the fingers and aspirating the remainder with a syringe complete evacuation is obtained. A small catheter (No. 14 French) may then be placed upon the collapsed bowel in its longitudinal axis and buried by a running suture of very fine silk or catgut. The writer's preference is to employ interrupted sutures of fine silk placed after the Halsted plain quilt or mattress pattern. After the suture has been partially completed (Fig. 48), a puncture is made with a cataract knife and the proximal end of the catheter is threaded into the gut; the interrupted silk sutures are continued for a short distance beyond, making a peritoneal tunnel in which the catheter lies (Fig. 48). After the catheter has served its purpose, as an emergency outlet for the intestinal content, granted that the normal avenue has again opened up as indicated by absence of escape of much gas and fluid through it, it may be removed by undoing its anchorage to the skin. No fistula develops for the tiny peritoneal tunnel invariably closes spontaneously. The writer has left the catheter for various reasons in the bowel for long periods of time—even after dismissal from the hospital. When the catheter is withdrawn even after the lapse of weeks, there is no leakage.

Methods of evacuating the gut by stripping at the time of the operation as advocated by Monks, Moynihan, Holden and Vandenberg are accompanied by considerable risk. Laewen, Morton, Ochsner and Storck, and Sperling and Kremen have pointed out that stripping of the bowel in the presence of acute obstruction and great distension is fraught with hazard. Yet if the emptying of the distended bowel by some such plan could be achieved with minimal manipulation of the bowel itself, taking great pains to avoid spillage, a method of extending helpful surgical aid to the late case will have been evolved. Introduction of a moderately large tube to which suction is applied would appear to offer less trauma to the distended bowel than stripping and drawing the distended bowel over a Monks-Moynihan evacuator. (See Caption Q below and Fig. 53.) The precipitous fall in pressure and associated ill consequences are probably not so much the result of sudden decompression as insisted by Elman, but rather the result of trauma to the gut wall. Wangenstein and Scott have shown that the fall in pressure attending decompression of a distended abdomen may be averted in part by preliminary adminis-

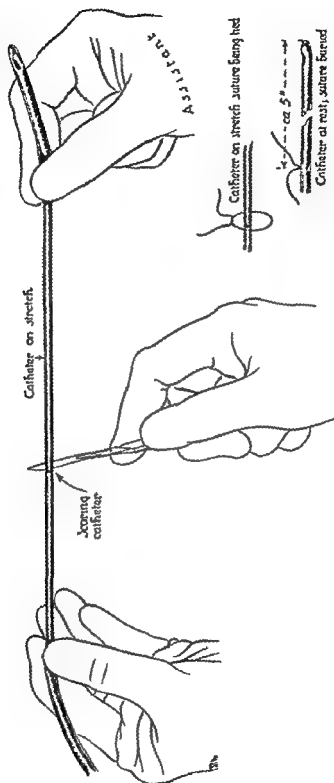


FIG 10—Method of scoring catheter to fasten it in the bowel (Arch Surg 26:958 1933)

closed, and tie catheters into proximal and distal loops, than to do a primary resection. The risk of making a primary anastomosis depends chiefly upon two factors: (1) The enhanced risk of peritonitis even with aseptic forms of anastomosis because of the tremendous increase in number of bacteria in the obstructed bowel and (2) abnormal fragility or reduced

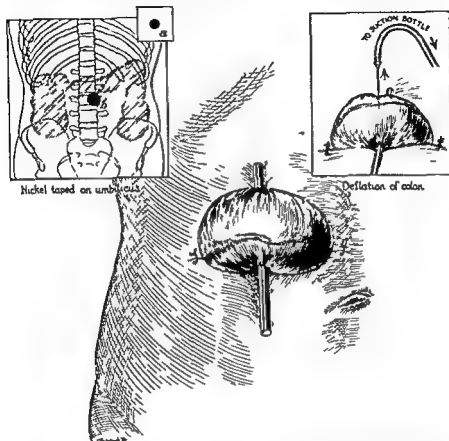


FIG 50—Technique of decompressing the distended colon. Sketch of a radiogram from a case. A five cent piece is taped over the umbilicus. In the insert on the left the actual size of the nickel drawn to scale is shown in *a*. The 33% enlargement on the anterior abdominal wall is shown in *b*. The intestinal coils within the abdomen are enlarged 25%. In the insert on the right the method of deflating the colon on completion of the operation is shown. After a few such aspirations the bowel is incised and a tube inserted before it is finally cut across. The tension in the bowel is determined before its contents are aspirated.

strength of the obstructed bowel even proximal to the strangulated gut. Where considerable gut is devitalized and especially where the fistula is high because of the impoverished alimentation and nutrition in consequence of loss of digestive juices, primary resection would be the lesser of the two evils. In the more usual circumstance especially if the devitalized gut is in the lower ileum or colon much less risk is assumed for the

tration of pituitary extract, adrenalin, and other drugs which sustain the blood pressure, as well as intravenous infusions. No such protective influence is provided by similar measures in the patient or animal whose gut is "stripped." The dog with obstruction of the small bowel tolerates "stripping" particularly badly under ether anesthesia. The same procedure under pentobarbital sodium anesthesia is somewhat better tolerated (Sperling and Kremen).

II DEALING WITH THE OBSTRUCTED COLON WITH ENORMOUS DISTENSION

Whereas a malignant or inflammatory stricture in the pelvic colon constitutes a simple type of obstruction, the presence of the proximal ileocecal valve and sphincter may convert the colon into a closed loop obstruction. The contents of the ileum are discharged into the cecum, but may not in turn be regurgitated back into the ileum. With the elapse of time and consequent upon the increasing distension, secretion from the mucosa of the gut is increased, while absorption is retarded. All the features of a strangulating obstruction may then become manifest in at least part of the gut, and usually in its most dilatable portion, viz, the cecum, where ulceration, gangrene, and perforation may be observed. When such a bowel wall has gradually been subjected to obstruction, its wall may hypertrophy considerably. Then when acute obstruction supervenes, the stress which would ordinarily cause rupture of a previously unobstructed gut may be withstood.

The roentgen film indicates quite accurately the extent and length of the gut concerned in the distension. As previously stated, the small bowel participates rarely in the distension. Inasmuch as subsequent operations remain to be done upon the obstructing agent, the site of colostomy must be somewhat removed from later sites of entry into the abdomen. The cecum, the usual site of decompression is not well suited for the performance of an aseptic tap, for it can rarely be delivered adequately to permit of segregating safely a segment upon which an aseptic decompression may be done. When the cecum remains the only site for the establishment of an outlet for intestinal content it is best to insert the catheter through the appendix or the terminal ileum, and, in the latter instance, finally through the ileocecal valve, unless the cecum can be delivered adequately. Another alternative but less acceptable procedure consists in circumscribing an area of the cecum with gauze and puncturing subsequently with a trochar.

When the greater portion of the colon is concerned in the distension, it is decompressed usually best through a high short, transverse right rectus incision, a glass rod being placed beneath the transverse colon. This method permits of complete deviation of the fecal stream, an item of no mean importance for the subsequent operations (Fig 50).

I MANNER OF DEALING WITH STRANGULATED BOWEL

On the whole, it may appear to be safer in the presence of great distension, to exteriorize devitalized bowel, cut it off when the skin is

to be governed by the comparison and by experience, together with the other points that we have brought out. The bowel wall at the point of resection when in the spastic stage should be nearly white in color showing that the capillaries are not thrombosed, since the blood is expressed from them by the force of the contraction. In obstructed bowel where the circulation is damaged and there is beginning gangrene, even though the bowel will contract it remains rather dusky in color, probably due to thrombosed capillaries.

Thirdly, we found that in suturing obstructed bowel the needle meets increasing resistance as one goes from badly damaged bowel wall to ward that which is approximately normal and this is one of the tests that we use to determine a suitable point. We feel that this is due to oedema of the submucosa since this layer is the layer that causes resistance to the passage of the needle. In doing the anastomosis there is always, even at the point of resection, some difference between the resistance to the passage of the needle through the wall of the upper end of the lower segment. This shows that even where anastomoses will hold and resection is safe this oedema still persists to some extent."

In performing resection with primary anastomosis for obstructive lesions in the small intestine non strangulating in character, the writer feels that the resistance encountered by the needle, in passing through the tissue is probably the most important determinant of a safe place at which to make the anastomosis. In strangulating obstructions it is also an important guide. However, in such instances, color changes and contractility of the gut are auxiliary aids. For purposes of orienting the surgeon with reference to resistance encountered by the needle in making the suture it is probably wise to start the suture in the bowel distal to the obstruction.

A. EXTERIORIZATION WITH FISTULA

The only anxiety the surgeon need have with the employment of enterostomy relates to (1) whether the loss of secretions may prove serious and (2) whether the intestinal continuity may have to be restored by another operation. The latter event is accepted for the patient without complaint by the surgeon when he relieves obstruction of the pelvic colon by colostomy. In the small intestine, continuity is frequently automatically recovered without added operation and the loss of fluid through an enterostomy opening will only prove serious when the fistula is high and the obstruction complete. High complete fistulas are to be deliberately avoided. When excision of non viable gut becomes necessary in the upper half of the small intestine exteriorization of the devitalized gut is to be avoided whenever possible. Connection of the two fistulous openings by means of a rubber tube and glass cannulas will temporarily help to avoid the disastrous results of a high fistula in those instances in which a primary anastomosis does not appear indicated until closure of the fistula can be made with less risk. With employment of the closed method of anastomosis surgeons are abandoning exteriorization more and more in favor of primary resections.

patient, with considerable intestinal distension, if a secondary anastomosis is made during the convalescence after initial exteriorization. If, however, the technical difficulties occasioned by distension do not loom large, primary resection, especially in the instance of obstruction of the small intestine is to be considered. Primary resection, wherever feasible, is becoming the policy and practice of this clinic. Employment of the closed anastomosis reduces, considerably apparently, the risks of the open anastomosis. This item will be dealt with at length, under the subsequent caption of primary resection.

J DETERMINING WHETHER THE BOWEL IS VIABLE

The criteria upon which one decides the viability of the bowel are essentially (1) the color, (2) the absence or presence of pulsations in the mesenteric arteries along the border of the bowel, and (3) the contractility of the muscle of the bowel wall when pinched. The most reliable of these is color. Distinctly viable and devitalized bowel can be recognized readily. In border-line cases, it is difficult to be certain by any method. The temperature of the strangulated gut has been determined by use of a thermocouple and it has been advocated that a superficial incision be made to note whether the bowel wall bleeds—a hazardous procedure. Failure of return to normal color and lustre of the bowel wall indicates that the blood flow has been seriously compromised. Persistence of a dusky color and engorgement of the mesenteric veins suggest that the bowel should be treated as though it were not viable. In doubtful instances, it may be exteriorized without opening it, if the color improves, the bowel may be returned to the peritoneal cavity.

With reference to determining the safe point for resection in obstruction, Owings and Smith (1932), who have given the matter special study, have the following to say: "The more experiments we did the harder we felt this point was to determine with any degree of exactness. We felt that the best things to judge by were first, the ability of the bowel to contract when mechanically stimulated, that is, not only ability to contract but to contract completely go into actual spasm. This spasm is readily induced by tapping the bowel with a clamp or pinching it or plucking it with the finger. It is important to notice whether this bowel at the height of its contraction comes down to the size that one would expect normal bowel to reach under similar stimulation, because this helps to determine the degree of oedema which is the best expression of the early reaction of the bowel to obstruction.

Secondly, the circulation of the bowel wall and the mesentery is very important. There should not be any oedema of the mesentery, and pulsations should be clearly seen and felt in the mesenteric vessels. The circulation in the bowel wall itself is best determined by its color during both spasm and relaxation. During relaxation a point should be picked where the color of the bowel wall changes from the dusky, non glistening color of damaged circulation to a point as near the normal pinkish glistening color as possible. This point is very hard to determine as the change is a very gradual one and the normal color is never actually reached. One has

to be governed by the comparison and by experience, together with the other points that we have brought out. The bowel wall at the point of resection when in the spastic stage should be nearly white in color showing that the capillaries are not thrombosed, since the blood is expressed from them by the force of the contraction. In obstructed bowel where the circulation is damaged and there is beginning gangrene, even though the bowel will contract it remains rather dusky in color, probably due to thrombosed capillaries.

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K. EXTERIORIZATION WITH FISTULA

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I DIETARY MANAGEMENT IN HIGH INTESTINAL FISTULA

An adequate nutrition can not, of course, be maintained over any great length of time without the greater portion of the small intestine being intact this is particularly true of infants and children. The baneful systemic effects of the profuse loss of vital fluids through a high intestinal fistula may be largely set aside over a short period of time by the liberal per oral administration of saline solution, and in part as well by the collection and return of the fluid drainage by proctoclysis or preferably through the distal fistulous opening.



FIG 51—Manner of dealing with an intestinal fistula when exteriorization is done for gangrenous small bowel. The fluid that drains away from the proximal loop is collected and is run into the catheter in the distal loop by the drip method. Primary closed resection has been done away largely with need for exteriorization in mid small intestine (See Fig 142 also) (Arch Surg 26:939 1933)

After the establishment of a complete fistula of the small intestine careful dietetic management is highly important. In a few instances of this sort, the writer has had the helpful co operation and assistance of Professor Irvine McQuarrie and his associates of the Pediatric Department of the University of Minnesota in providing a suitable diet for such patients. Fat apparently enhances the motility of the gut and decreases the time over which an abnormally short gut surface must absorb the digested food. A high carbohydrate and protein diet seem to be most readily assimilated, and less food appears in an undigested state at the fistulous opening. The absorption of proteins

which are assimilated readily appears to be an important item in preserving a normal water and salt balance. Despite the liberal administration of intravenous saline solution to such a patient, the tissues do not seem able to hold water until protein is being absorbed from the gut. Milk, skim milk, lactose cheese, eggs, cooked cereal, ground liver, candy, yeast, cod liver oil and orange juice have furnished the basis for a satisfactory diet in instances of high ileal fistula. The caloric value of the food served and that not eaten should be carefully estimated and recorded. A daily caloric intake of about 2000 to 2200 calories can be provided with such a diet giving 250 to 275 grams of carbohydrate, 90 to 100 grams of protein, and 70 to 80 grams of fat. A formula containing a mixture of glucose, milk, eggs, peptone and yeast constitutes a satisfactory preparation to run into the distal fistulous opening by the drip method to augment the oral intake of food. If need be caloric and nitrogen balance can be maintained by intravenous feeding (see page 245).

The formula of Scott and Ivy, which the writer has had occasion to

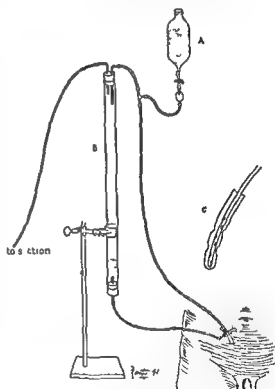
employ on many occasions, contains the following proportion of ingredients

TABLE XXII—INGREDIENTS OF THE SCOTT ILY FORMULA FOR JEJUNAL ALIMENTATION

Water	300 cubic centimeters
Cane sugar	15 grams
Peptone (dried)	10
Wheat flour	30
Milk (whole)	200 cubic centimeters
Cream (20 per cent)	100

One hundred cubic centimeters of this formula contains approximately 80 calories. However, when entering the intestine at a low

FIG 52—MacNaughton's scheme for carrying away intestinal secretions from an intestinal fistula. Fluid is allowed to run under the influence of gravity from the drip bottle (A). The use of a Sprengel water pump creates a negative pressure in (B) the subatmospheric pressure causes the fluid escaping from A to be drawn over into B with the establishment of a siphonage force in the fistula. A perforated glass tube (C) surrounds the catheter in the fistula. (MacNaughton Surgery 9 372 1941)



level, its food value because of the imperfect digestion, is considerably less. If diarrhea attends the drip feeding of this formula, the amount of fat is to be decreased. In addition, a sufficient quantity of saline solution should be given by vein or by proctoclysis to insure a satisfactory urine output. When the patient's condition permits, the fistula should be closed. The dietary regulations here outlined have proved helpful in enabling the patient with a high intestinal fistula to gain weight when his status could not be satisfactorily maintained on an ordinary regimen.

Kirschner's jejunostomy feeding mixture has been used in this clinic

with some satisfaction. The ingredients are indicated in the accompanying table.

TABLE XXIII—KIRSCHNER JEJUNOSTOMY FEEDING MIXTURE

1750 cc whole milk	1225 calories (100 cc = 70 calories)
50 ■ barley meal	200 calories (100 ■ = 400 calories)
50 g glucose	200 calories (100 ■ = 400 calories)
200 cc cream	400 calories (100 cc = 200 calories)
5 ■ table salt	

Total Volume 2055 cc
Approximately 1 calorie per cc

2025 calories

The experience of this clinic suggests that the ideal formula for feeding through an enterostomy has not been found. Trial and error, with temporary periods of alimentation by the intravenous route, until the proper adjustment is made, continues to be the method that must be applied in a number of instances. The Walters and Hartman formula, employing an ice cream base has been used with satisfaction in a number of instances. Our experience with it suggests that the fat content should not be increased beyond that suggested by Walters for the third day feeding. The formula appears in the accompanying Table.

TABLE XXIV—WALTERS HARTMAN JEJUNOSTOMY FEEDING FORMULA

	Day on Which Diet is Employed		
	1st	2nd	3rd
Total cc per hour	30	30	60
Total cc per day	720	720	1440
Ingredients			
Ice cream mix Gm	150	200	400
Skim milk powder Gm		25	50
Eggs			1
Dextrose Gm	25	25	60
Ascorbic acid mg			25
Halibut liver oil drops			15
Thiamin chloride mg			3
Water cc	570	520	990
Composition			
Carbohydrate	47	65	139
Protein	6	15	36
Fat	21	30	66
Calories	401	590	1,294

Walters and Hartman have the following to say concerning the preparation of their formula. Ice cream mix as used in making ice creams in most institutions is a combination of whole milk powder, ice cream or butter fat, egg powder and gelatin (carbohydrate 15 Gm, protein 4 Gm, fat 14 Gm). The mix is homogenized and has been more successfully used in making the formula than the milk and cream mixture formerly employed. More normal stools result in cases in which it has been used. Method of preparation. Mix skim milk powder with water to make a smooth paste. Add the remainder of the water specified for that particular formula, dextrose and ice cream mix. Beat the eggs, add halibut liver oil and beat again. Combine these mixtures, strain and add dissolved ascorbic acid and thiamin chloride. Individual feedings should be warmed to body temperature in hot water before administering.

M PROTECTION OF SKIN

For protection of the skin in the presence of a fistula when the drainage is profuse and the fluid can not conveniently be collected through a catheter, employment of a Sprengel water type of suction apparatus is found particularly useful. MacNaughton has described, recently, a simple but effective device to obviate spillage from an intestinal fistula, onto the skin (Fig. 52). Covering the skin adjacent to the fistula with yeast, as described by Mead, is a simple and one of the most effectual means of preventing excoriation of the skin. A yeast cake is made up into a batter with water and is applied over the skin. Its chief drawback is that when the yeast dries, it cracks and has to be removed, necessitating rather frequent applications of fresh yeast batter. A five per cent tannic acid ointment has been found to be very effectual. Another useful expedient is an ointment of 25 per cent metallic aluminum with a vaseline base.

N ENTERO ANASTOMOSIS

The indications for the performance of entero anastomosis are not easy to define. In the main it is the writer's impression that entero anastomosis has rather limited indications in the presence of acute intestinal obstruction with great distension. Entero anastomosis is to be reserved for those acute obstructions in which enterostomy, exteriorization with the establishment of a temporary complete fistula, or primary resection will not do. The performance of an entero anastomosis assumes that the bowel is viable and that the obstruction itself is irremovable or that its removal should be left to a more opportune time. There are, however, occasions when no other procedure seems to meet the situation as well. In a recent instance of displacement of the upper jejunum beneath a gastrojejunal anastomosis occurring several months after gastric resection for ulcer causing acute obstruction no other operation appeared to satisfy the requirements of the situation. After deflation of the distended loop by needle aspiration (Fig. 47b), 750 cc of yellowish stercoraceous fluid being removed, entero anastomosis by the closed method was made easily with recovery of the patient.

Morton (1932, 1937) has had considerable experience with entero anastomosis in certain types of obstruction, and is probably one of its strongest advocates. The writer believes that the chief place for entero anastomosis lies in the special indication as cited above, or in the less acute or chronic varieties, as exemplified by obstruction of the bowel by tumor. Yet even here if entero anastomosis can be performed with safety, excision with primary resection should be the preferable procedure. There remains however the case in which an entangled mass of adhesions constitutes the obstructive mechanism. Enterostomy in such cases, in the opinion of the writer, is the operation of choice. Yet there are circumstances which suggest that entero anastomosis is occasionally the procedure of choice. Any anastomosis in the presence of obstruction should be made by the closed technique.

It is not to be forgotten, however that there are certain remote risks

which attend employment of entero anastomosis Estes and Holm and Pearce have warned that distension and obstruction may occur in side tracked loops As a matter of fact, resection by exclusion is an old principle in the management of carcinoma of the colon Its use has been described successfully by V Hacker, Salzer and others When the short circuited loop is not long and the obstruction for which the entero anastomosis is done is incomplete, the remote hazards described by Estes and Holm, and Pearce are probably of no great importance For a patient presenting an anemia of obscure origin, the writer excised such an entero anastomosis, which had been made 18 years before An ulcer was found in the loop distal to the anastomosis The anemia was cured and the patient has remained well for more than 5 years

The performance of entero anastomosis between the small intestine and the colon, on the indications suggested by Sampson Handley in so called "ileus deplex" is ill advised

O ATTACKING THE OBSTRUCTIVE MECHANISM DIRECTLY IN SIMPLE OBSTRUCTIONS

Enterostomy is, at best, a compromise procedure Often, however, the surest way of attaining an objective is through the indirect measure of compromise Under the section of Enterostomy, some of the hazards, that confront the surgeon who elects to attack the obstructive agency directly, are described The writer speaks from bitter lessons learned from personal experience It is the case of simple obstruction, presenting an entangled mass of adhesions, that the writer would caution the surgeon from attacking directly, in the presence of great distension The single adhesive band is a different matter It may be divided usually with safety However, it is to be remembered, after several days of occlusion, that adhesive band and gut wall may be fused into one Traction or manipulation of the adhesive band may open the bowel with consequent spillage—an occurrence which seals the doom of the patient almost invariably, because of the presence of high bacterial counts in obstructed intestinal content

When, however, the obstruction concerns a gall stone or other impacted solid body, it must be removed usually The technique for the removal of an obstructing gallstone, depicted on page 320 has proved very satisfactory It permits removal of the stone without contamination The management of a tumor of the bowel is discussed under the caption of Primary Resection The suggestions outlined under methods, of dealing with distension at operation to reduce the risk of primary resection in gangrenous obstructions, apply equally well here He who essays to deal directly with obstruction, must be in a position to deal effectually with the problem of distension, if need be

P RESECTION WITH PRIMARY ANASTOMOSIS

Like entero anastomosis, primary resection has definite indications in obstructions, in the upper jejunum when the bowel viability primary resection is in order In all extensive procedures the bowel has lost its viability, as typified by mesenteric

thrombosis or volvulus of the small intestine, excision and primary anastomosis are indicated. The establishment of an external fistula in such instances *must not be done*. In gangrenous processes of less or length situated in the upper jejunum primary resection is likewise the operation of choice. When such gangrenous processes involve the lower ileum, the general tendency, in the main, has been to favor exteriorization, on the principle that it is the procedure of lesser risk, and that fistula is well tolerated at this level, even in infants. In strangulated hernias, intussusception with non-viable bowel, volvulus and devitalized bowel occasioned by adhesive mechanisms, it is becoming more and more the practice of this clinic to do primary resections. My associate Dr. Clarence Dennis, together with senior surgical house officers in this clinic, has during the past year, done 8 consecutive primary resections for non-viable strangulations of the small intestine with no mortality. One of these included an infant of two months with an irreducible gangrenous intussusception, for which a primary end to end anastomosis of the ileum was made. In gangrenous processes in the colon, however, in the presence of distension the exteriorization principle is still the operative procedure of choice. Under the section on Volvulus, it is pointed out that Muschkat (1932) advises a primary extraperitoneal end to end anastomosis after resection of non-viable segments of torsioned pelvic colon. Koster (1940) has advised recently, such extraperitoneal placement of the anastomosed segments of the colon, following primary resection of unobstructed lesions. Such a practice indicates little confidence on the part of the surgeon, to make a satisfactory anastomosis.

In the presence of a tumor of the small bowel causing acute intestinal obstruction, the indication for primary resection is not so compelling. If distension does not loom as too formidable a problem, primary resection, employing the closed anastomosis would be the first choice of operative procedure in this clinic. Alternative schemes which could be employed are 1) entero anastomosis 2) exteriorization and 3) enterostomy for the relief of acute obstruction.

If excision of the lesion *per se* presents no great problem, primary resection with end to end anastomosis may be done with about the same risk as entero anastomosis. In the presence of great distension, enterostomy or exteriorization with temporary fistula formation would have to be given consideration.

Q. ADDITIONAL METHODS OF DEALING WITH DISTENSION AT OPERATION TO REDUCE THE RISKS OF PRIMARY RESECTION

This writer has pointed out, on every occasion on which he has expressed himself on the bowel obstruction problem, that an enterostomy, when properly done, is a good and safe operation. It is obvious that neither needles nor sutures can be passed with impunity through a distended paper thin bowel wall. A leak will occur at every puncture. If however the content of a segment of the bowel is evacuated by the milking process and the segment is segregated between clamps and the remainder of the content of the loop emptied by needle aspiration (see Figure 47), catheter

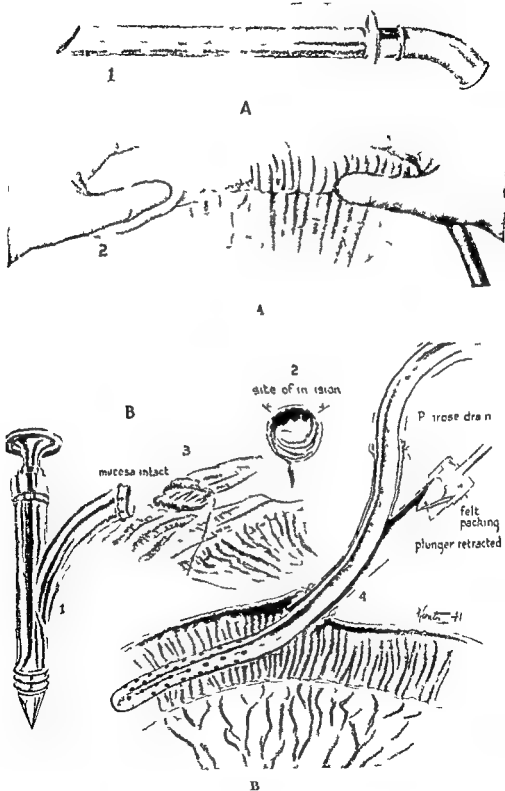


FIG 53 (See page 209 for explanation)

enterostomy can be done with safety. Within the space of a few seconds, the paper thin bowel wall acquires substance, permitting placement of sutures.

If primary resection is contemplated, in the presence of a satisfactory indication, it is obvious that the distension in the proximal obstructed segments of bowel must be dealt with. In some instances, the method employed in enterostomy will suffice. In others, multiple needle aspiration carried out on the same plan may do. A distinct advantage in eliminating the perplexing item of distension from long segments of bowel, is that better orientation may be reached concerning the exact nature of the obstructing mechanism—an item of great importance, in instances when so formidable a procedure as primary resection is contemplated.

Extension of use of the method suggested by Monks and endorsed by Moynihan and Holden suggests itself as a possibility for emptying the distended bowel. The potential source for contamination—a dangerous accident, is apparent. Further, Læwen, (1927) Morton, (1932) Ochsner and Storch (1936) and Sperling and Kremen (1939) have pointed out, that stripping of the bowel in the presence of acute obstruction and great distension, is fraught with hazard. Yet, if the emptying of the distended bowel by some such plan could be achieved with minimal manipulation of the bowel itself taking great pains to avoid spillage a method of extending helpful surgical aid to the late case will have been evolved.

Aseptic Decompressive Suction Enterostomy

There are occasional instances, when it becomes mandatory to deal effectually with the factor of distension, at operation. Instances in point are (1) occlusion of the bowel by an adhesive band, deep in the pelvis which can not be exposed for visualization because of the existing dis-

FIG. 83 Operative methods of achieving decompression of the distended small intestine

A The Monks Moynihan procedure. In (1) is shown the tube (2) indicates the method of stripping the distended bowel and reefing it on the tube.

In this method the fluid content of the distended bowel escapes by siphonage.

B The writers plan of aseptic decompressive enterotomy. A loop of distended small bowel is emptied and segregated between clamps as indicated in Fig. 47A (or as in 47B). (1) The instrument constructed on the general plan of an empyema trochar. (2) The site of the transverse incision. (3) Placement of a fine catgut purse string suture the incision extends to the mucosa. (4) A long urethral tipped tube with multiple small perforations is introduced through the side arm of the enterotomy. Penrose tubing longer than the rubber tube is fastened to the side arm of the trochar at one end and to the proximal end of the rubber tubing at the other. Glycerine is placed within the Penrose drain tubing before it is drawn over the suction tube—this maneuver permits the suction tube to be advanced or withdrawn with relative ease. The purpose of the Penrose tubing is to prevent soiling of the operator's hands by the suction tube when the latter is withdrawn from the bowel.

With a Y glass tube connected to the rubber tube and a source of active suction a non sterile assistant may make and break the suction force. Decompression sufficient to permit evacuation of the contents of several distended intestinal loops may be accomplished by this agency with less hazard of spillage and with far less trauma to the intestine than with stripping of the bowel in the case of the Monks Moynihan tube.

tension Enterostomy is an alternative procedure in some such cases Yet, drainage of the intestinal canal alone, without removal of the obstructing band, leaves a great deal to chance The writer has observed penetration of the bowel wall, by the constricting band, with ensuing peritonitis, when such an obstruction was treated by enterostomy alone, (2) obstruction occasioned by a tumor or other obstructive mechanism which might be removed with reestablishment of intestinal continuity by primary resection This latter indication, under ordinary circumstances, represents, often, only an extension of the principle of primary resection, however, it, too, like the first indication (occlusive adhesive band), may become a matter of necessity, constituting the safest and most effective manner of dealing with the obstructing agency

The objection to use of the Monks Moynihan principle of intestinal evacuation is that, the maneuver of stripping damages the bowel and threatens the life of the patient (Fig 53A) The writer conceives of dealing with the item of distension, in those instances in which operative decompression is necessary to visualization of the site of obstruction and its management, in the manner depicted in Fig 53B Employing an enterotomy evacuation cannula, resembling in principle an empyema trochar, operative decompression may be achieved by advancing a long, moderately stiff rubber tube into the bowel lumen (Sizes 20, 24, and 30 French have been used) In the placing of the cannula, the care observed in the making of an ordinary enterostomy must be taken, to avoid spillage (Figs 47 and 48) The catheter with many small perforations like the Kenyon-Pool metal abdominal suction tube is advanced slowly into the distended gut In this maneuver, *suction can be employed* to deal with the distension rather than the manipulative procedure of the Monks-Moynihan method of intestinal evacuation A distended loop in the vicinity of the obstruction should be chosen for evacuation Monks devised intestinal evacuation to wash out toxic material from the distended bowel The writer employs the procedure outlined here, which may be described as aseptic decompressive suction enterotomy, to reduce distension in suitable instances, such that the surgeon may see and deal, intelligently and effectually, with the obstructing agency All the distended intestine need not be decompressed, therefore, as a prelude to dealing with the obstruction itself

Some reefing of the bowel upon the catheter is necessary in accomplishing decompression by the method described here However, such manipulation does not concern the distended bowel Only after a distended loop has been emptied by suction need it be drawn over the catheter to permit decompression of more proximal reaches of distended intestinal coils Pressure upon gaseous distended coils of bowel will facilitate decompression, and gentle elevation of coils distended with fluid will aid in bringing the contents of the distended segment within reach of the aspirating tube The catheter may be withdrawn from the bowel and advanced in the other direction if desired The Penrose tube drain (see Caption Fig 53B) overlying the aspirating catheter precludes contamination of the surgeon's hands on withdrawal of the tube The glycerine within the Penrose drain facilitates manipulation of the aspirating catheter

Enterostomy will continue to have a wider field of usefulness than aseptic decompressive suction enterotomy. Yet, this latter procedure will enhance the ability of the surgeon to deal with certain obstructions, presenting great distension, more effectually and with greater safety to the patient. It is the practice of this clinic to implant 2 to 4 grams of sulfathiazole about openings or anastomoses made in the bowel.

The scheme of operative decompression depicted in Fig 53B and described here has been used successfully and with satisfaction at operation upon a patient with an obstruction of seven days' duration, in whom an adhesive band, deep in the pelvis, occluded the bowel completely. After aspiration of the intestinal loop involved, the band could be visualized and cut. It was fused intimately with the bowel wall. After severance of the band, the gut appeared to be intact. Gentle manipulation demonstrated that the band had cut deeply into the bowel, the lumen being entirely open, over three fourths of the circumference of the bowel. Only at the mesenteric attachment was the gut wall intact. The bowel having been sucked out there was no spillage and the patient recovered. Performance of "blind enterostomy" in such a patient would, in all probability have been doomed to failure from the start.

R PARTIAL ENTERECTOMY IN AN UNOBSTRUCTED INTERVAL FOR RECURRENT OBSTRUCTION DUE TO ADHESIONS

An operative procedure which has come to be performed more frequently in this clinic, is partial enterectomy for recurrent obstruction due to tangled masses of adhesions. Since the first edition of this book was published in 1937 a fairly large number of recurrent obstructions have been operated upon, on this plan. Previously, enterolysis, as described under the Chapter on Adhesions, was done largely. Partial enterectomy, with sacrifice of that part of the bowel involved in the snarl of adhesions, has proved to be a far superior operation. Mere lysis of the gut in such instances is followed too frequently by recurrence of the obstruction. An aseptic oblique end to end anastomosis, in practiced hands, carries minimal risk and presents the distinct advantage of getting rid of the focus, which continues to foment obstruction.

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CHAPTER VIII

THE CLOSED ASEPTIC RESECTION

THE CLOSED anastomosis, though by no means new, has been slow to acquire momentum. In colonic resections, the method has had isolated proponents and adherents but, in the main, the open anastomosis has continued to be the anastomotic procedure practiced most widely. Halsted and his pupils experimented for years with technical maneuvers to facilitate performance of the closed anastomosis. And though Halsted, in his lifetime, did not succeed in developing an aseptic method of anastomosis, wholly to his liking, he stimulated a good deal of interest in the subject and his teachings have had a profound influence on modern practice.

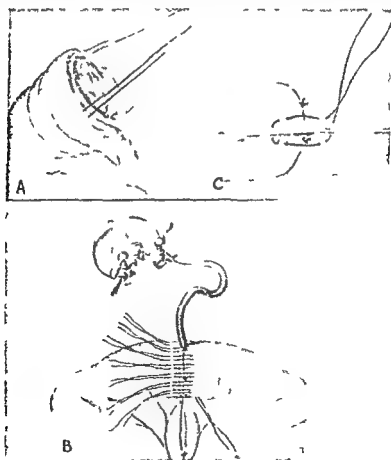


FIG 54—Techniques suggested by Halsted in the making of an end-to-end anastomosis. A Placement of presection sutures to avoid eversion of mucosa. B Inflation of a small cylindrical balloon to facilitate placement of sutures in end-to-end anastomosis. C Mode of dealing with the mesenteric angle—the so-called Mitchell Hunner stitch. (Collected papers The Johns Hopkins Press)

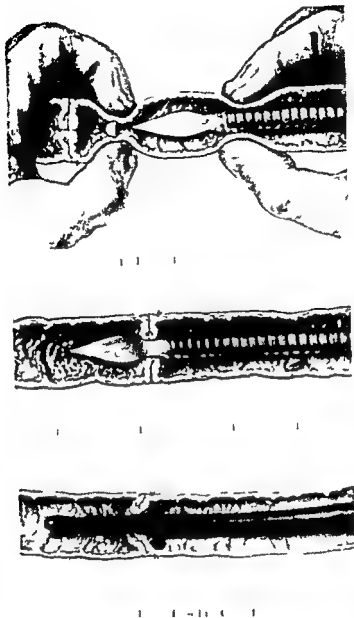


FIG 55—Method suggested by Halsted to accomplish primary resection and anastomosis by the closed method in the pelvic colon (Collected papers The Johns Hopkins Press)

At one time he employed an inflatable rubber balloon with which to establish continuity in the small intestine after resection (Fig 54) One of his last papers dealt with a means of establishing a closed anastomosis in the pelvic colon, after resection (Fig 55)

The basting stitch, advocated by Parker and Kerr (1908), was the first

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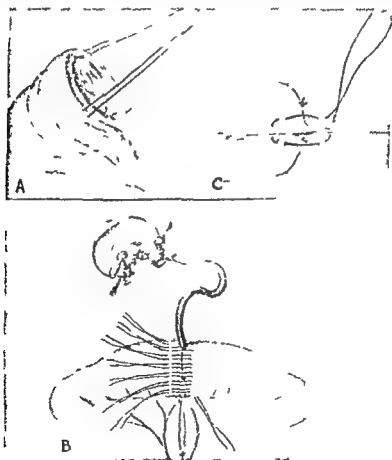


FIG 54.—Techniques suggested by Halsted in the making of an end-to-end anastomosis. A Placement of presection sutures to avoid eversion of mucosa. B Inflation of a small cylindrical balloon to facilitate placement of sutures in end-to-end anastomosis. C Mode of dealing with the mesenteric angle—the so called Mitchell Hunner stitch. (Collected papers The Johns Hopkins Press.)

colectomy for multiple neoplasms, in which the greater portion of the colon, save the cecum and a portion of the ascending colon, are sacrificed, an end to side union between the end of the pelvic colon and the cecum constitutes the simplest method of re-establishing intestinal continuity. Side to side anastomoses are reserved for the occasional entero-anastomosis necessary after gastric resection, and as a side tracking operation in intestinal obstructions, presenting a suitable indication. Gastrojejunostomy is of course, a side to side anastomosis, but it is performed today in most clinics far less frequently than 5 years ago.

All of these anastomoses may be made by the closed (aseptic) method. As was pointed out above, however, wherever feasible, the oblique end to end anastomosis, in intestinal resections is carried out, as the procedure of choice.

A TECHNIQUE OF OBLIQUE END TO END ANASTOMOSIS

Making an oblique anastomosis has two distinct advantages: 1) It permits sacrifice of a greater length of the antimesenteric border of the intestine, insuring, therefore, the best possible vascularization of the anastomosed segments; 2) It affords an excellent opportunity to increase the length of the stoma, in segments of bowel where the diameter is small.

The technical steps in the making of the anastomosis are indicated in the accompanying sketches (Fig. 57). The technique of all the anastomoses, whether end to end, end to side or side to side, is essentially the same. In the lateral anastomosis, the cuff of bowel above the clamp need not be cut away, until the posterior portion of the anastomosis has been completed. The clamps which may be employed for any type of closed anastomosis are shown in Fig. 60. The technique described here was evolved in establishing an end to side anastomosis after gastric resection. The attachment of the mesenteries of the stomach made it mandatory to complete the posterior portion of the anastomosis before placement of any of the anterior sutures. Yet, as the accompanying diagrams suggest, this method constitutes a practical and satisfactory manner of making intestinal anastomoses as well.

Briefly, the anastomosis consists in placing a row of interrupted sutures of fine silk (2 pound strength test) in accordance with the plain quilt Halsted mattress pattern. In the placement of these sutures, one of two plans may be used. All the sutures may be placed and tied only after all the sutures have been taken, or 3 or 4 guide sutures may be placed, one at either end and 1 or 2 between. The latter scheme affords opportunity to put gentle traction on the sutures and results therefore usually in the placement of a few more sutures than if all the sutures are placed before any are tied. Anyone who employs these 2 schemes will soon instruct himself in the variability of the state of stretch or contraction of the bowel wall.

The writer aims to place the interrupted silk sutures about 2 millimeters apart, embracing slightly less than this distance in the grasp of the mattress stitch. Fine curved needles, already threaded, and suitable small needle holders are employed routinely (Fig. 44). When the sutures

technical procedure, in the execution of a closed anastomosis, that acquired any vogue amongst American surgeons. A number of surgeons continue to establish intestinal continuity by this method. The development of special clamps by Rankin, Martzloff, and Stone lent increased impetus and interest in the closed method of effecting intestinal continuity, after resection of a segment of intestine. In 1940, the writer suggested that all anastomoses, in the gastro intestinal canal, including gastrojejunal as well



FIG. 56—A scheme devised to circumvent the difficulty of the mesenteric angle in end to end anastomosis of the small bowel (Redrawn from Horlev and Bigger *Operative Surgery* Volume II p 1070 5th Edition C V Mosby Company 1940)

as esophagojejunal after total gastrectomy, could be made by the closed method. Over a period now of about 4 years in length all anastomoses in the alimentary canal have been made by employing the closed method in this clinic. Gastric resection by the closed method has proved eminently practical. In this clinic, the closed aseptic anastomosis has come to displace the exteriorization operation of Bloch, Paul and Mikulicz, in treating malignancies of the colon. Preliminary colostomy is made only in obstructed cases and complementary enterostomy or colostomy has been done away with largely.

The standard method of establishing intestinal union has come to be oblique end to end anastomosis, whether the resection is made in the small or large intestine. After resection of the right colon, intestinal union is re-established by an oblique closed anastomosis between ileum and transverse colon. Primary resection with oblique end to end anastomosis is made for lesions of the transverse colon, as well as the pelvic colon. End to side, or side to side anastomoses, all of which may be made by the same technique are reserved for the unusual case. Esophago jejunostomy after total gastrectomy and the gastrojejunal union after gastric resection by choice are made as end to side anastomoses. After primary subtotal

in the posterior row have been placed, all the sutures are cut 2 millimeters above the knot. The second row, posteriorly, the suture nearest the clamp, is usually a running suture of fine catgut (000). The interrupted Cushing mattress suture of silk is also a satisfactory stitch for this layer. The



FIG 68.—Solution of the difficulty of the mesenteric angle. A Placement of the clamp upon the bowel wall at an acute angle (about 45°). The external row of sutures will come within the confines of the dotted line—that is, the first posterior row and the last anterior row will not be more than 75 of a centimeter (preferably 5 cm) away from the clamp. B Detachment of the mesentery to a point 75 cm beyond the site of application of the clamp is an oblique end-to-end anastomosis permits placement of every suture in the bowel wall. The mesentery is not employed in the anastomosis. The manner of dealing with the mesenteric angle shown here concerns the small intestine; the same technique is employed in resections of the colon. The preparation of the colon for the anastomosis (Fig 59) is a little more difficult.

anterior rows are then placed in the reverse order: first the suture nearest the clamp and finally the outer row of interrupted Halsted mattress

ant holds the bowel under tension while the surgeon places the first few guy sutures. To one unaccustomed to the capacity of the small intestine to accommodate itself to varying states of contraction, this stretch of the bowel under gentle pull may seem extraordinary. B Three guide sutures of fine silk put after the Halsted mattress pattern have been placed in accordance with the plan suggested in A. These three sutures are tied and enough additional sutures are placed to make a satisfactory approximation. The sutures are placed a little less than 2 millimeters apart and the grasp of the tissue within the mattress suture is slightly less in width than the spacing of the sutures. C The inner posterior row of running 000 catgut. D The single ferrule have been removed; the clamps have been rotated and the anterior inner row of running catgut has been placed. The straight mosquito clamps identify the ends of the posterior catgut suture and the curved mosquito clamps are attached to the anterior suture. E Technique of detaching the ferrule. A tissue forceps is engaged behind it and a few taps from a hammer dislodge the ferrule. F The completed anastomosis after placement of the outer anterior row of Halsted mattress sutures of fine silk.

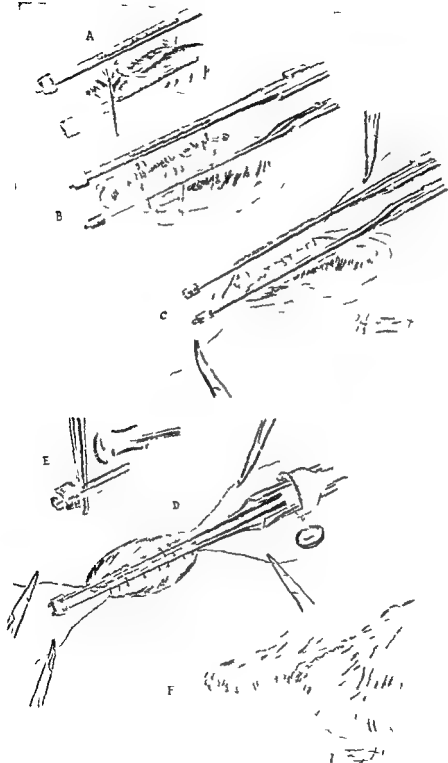


FIG. 57—Aseptic (closed) oblique end-to-end anastomosis in the small intestine. A Beginning the first posterior row. In order to avoid turning in a wide cuff the assist

sutures. The manipulation of the clamps is described in the caption of Fig. 57.

The Halsted stitch effects a nicely everted border and results in maximal approximation of peritoneal surfaces. All sutures in the closed anastomosis are placed, of course, from the peritoneal side of the bowel, and the caution urged by Halsted to place each suture into the submucous coat of the bowel must be observed. The writer came to employ catgut for the inner row, when after gastric resection an occasional suture was observed, now and then on gastroscopic examination, dangling from the suture line. If Halsted's teaching on this point is correct, such sutures must have penetrated the mucosa at the time of operation. For, Halsted holds that sutures will penetrate toward the mucosa only if the surgeon entered the mucous layer with his needle.

D. MANAGEMENT OF THE MESENTERIC BORDER

In the end to end anastomosis, management of the mesenteric border has been always a special problem. Halsted employed the scheme shown in Fig. 54. This purse string type of suture, directed at effecting adequate closure at the mesenteric border, Halsted called the Mitchell Hunner stitch. Horsley and Bigger depict the scheme of rotating the bowel employed commonly to lessen the problem of safe closure at the mesenteric angle in end to end anastomosis (Fig. 56). However if the anastomosis is made obliquely, no matter whether in the small intestine or the colon, it is quite safe, and the writer's routine practice, to detach the mesentery three fourths of a centimeter ($\frac{3}{4}$) beyond the site of section of the bowel. The angle of division of the bowel is usually 45° or less. Such mesenteric detachment makes it possible to employ the same scheme of closing the mesenteric angle as in the rest of the bowel. Unless the mesentery is detached beyond the site of section of the bowel, it is not feasible to provide satisfactory closure at this troublesome point. Mesenteric detachment as described above and illustrated in Fig. 58 does away with this problem wholly. Every suture should be placed in the gut wall. The mesentery must not be relied upon to close the intestinal defect.

C. DEALING WITH THE EPIPLOIC APPENDAGES IN COLONIC ANASTOMOSES

A number of studies have shown that the fatty tags on the exterior of the colon play a role in the transport of blood to and from the bowel wall, that is these colonic appendages have vascular connections with the bowel wall. Nevertheless the writer has come to deal with them as with the mesentery of the bowel (Fig. 59). No suture of the colon can be regarded as safe unless the surgeon knows that every suture has been placed in the bowel wall itself. Grasping a fatty epiploic appendage overlying the bowel wall, in a suture, is not an acceptable substitute for careful placement of each stitch into the proper layer of the bowel. Here, as at the mesenteric border the writer lays bare the true peritoneal surface of the colon for three fourths of a centimeter ($\frac{3}{4}$) beyond the proposed site of section of the bowel.



FIG 59—Mode of preparing the colon at operation for an oblique end-to-end anastomosis A The dotted line indicates the proposed site for application of the clamp B The fatty tags are under-run with a dissector Each fatty tag is divided and tied as indicated to obviate hematoma formation The bowel wall is to be cleared for a distance of $\frac{1}{4}$ of a centimeter beyond the proposed site of section This maneuver permits the surgeon to place each suture directly in the bowel wall

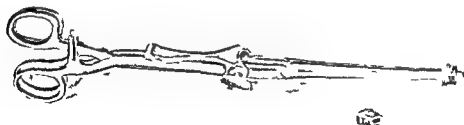


FIG 60—Resection clamps for the closed anastomosis The sketch shows the two clamps approximated with the double ferrule and the holding device over the shank Each clamp has a single ferrule as well These clamps patterned after the Martzloff instrument are adaptable for resections in small or large intestine as well as for gastric resections including total gastrectomy (Made by V C Mueller & Co Chicago)

Inversion of one half to three fourths of a centimeter ($\frac{1}{2}$ to $\frac{3}{4}$) of the adjacent edges of the walls of the colon affords satisfactory approximation. The area of inversion should be only broad enough to insure satisfactory healing. Inversion of more tissue results in narrowing at the site of suture and flap formation as shown in Figs 65 and 66. The writer has not observed compromise of the blood supply of the colon by removing all fat, including fatty epiploic appendages three-fourths of a centimeter ($\frac{3}{4}$) beyond the point of section of the bowel, in *oblique* end to end anastomoses.

D OBSTRUCTION AT GASTRO-JEJUNAL STOMAS

A troublesome complication of anastomotic procedures accompanying gastric operations, whether gastrojejunostomy or gastric resections, has been obstruction at the stoma and usually at the efferent outlet. Whereas a number of causes have been alleged to implement the occurrence of this complication, such as the length of the afferent loop, the direction of the anastomosis, whether iso or antiperistaltic, and the site of the anastomosis upon the stomach, the likelihood is that of obstruction at the efferent outlet is brought about largely by oversuturing. That is, the inversion of too great a width of the adjacent edges of the gastric and jejunal walls gives rise to flap formation, with the result shown in Fig 66. It is not likely that hypoproteinemia plays an important role in its genesis, ordinarily. Chauncey (1939) failed to observe any direct correlation between the plasma protein values and the occurrence of stomal obstruction after gastrojejunal anastomoses. Since observing the rule of not inverting more than three-fourths of a centimeter ($\frac{3}{4}$) of the adjacent walls of jejunum and stomach, no instances of obstruction at the efferent outlet after gastrojejunal anastomoses have been observed in this clinic, in more than 150 consecutive such anastomoses.

As Fig 66 indicates, obstruction at the afferent inlet in gastrojejunal anastomoses is not likely to occur through the agency of over inversion. For, the flap thus created does not obstruct the stoma of the inlet, as does a similar flap at the gastric outlet. Angulation of the bowel is the most likely cause that may bring this situation about. The transverse mesocolon should be anchored to the stomach above the line of the anastomosis.

sutures are placed as indicated and then tied. One or 2 sutures are then placed between the guy sutures. Thus the outside row of sutures should not be at a greater distance than $\frac{1}{4}$ of a centimeter from the clamp. B The inner posterior row a running suture of 000 catgut. Interrupted Curshing mattress sutures of fine silk may be used for this layer. The ferrules are knocked off the clamps before they are rotated for placement of the anterior row of sutures. C The double ferrule has been placed over the tips of both blades and the locking device fastened over the mid portion. A running suture of catgut is placed near the clamps anteriorly. It is to be noted that straight mosquito forceps are employed to identify the posterior catgut sutures while curved mosquito clamps are used for the same purpose anteriorly. D The clamps have been withdrawn, the anterior and posterior catgut sutures at each end have been tied together and placement of a row of interrupted Halsted mattress sutures completes the anastomosis. No portion of the mesentery is employed to secure closure at the mesenteric border.

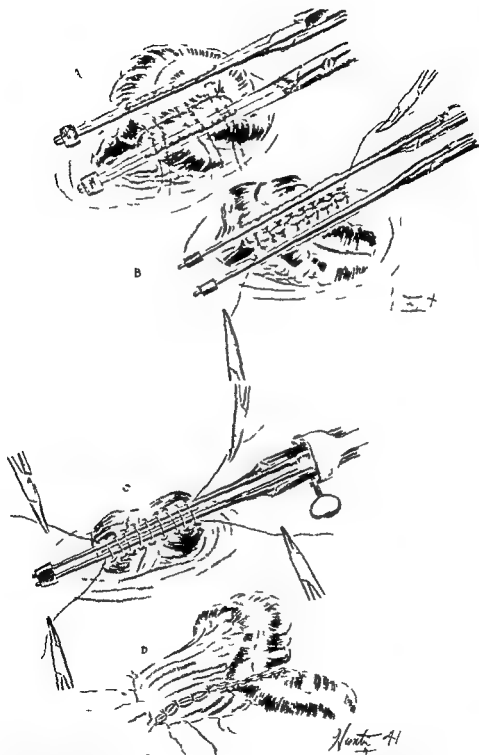


FIG 61—Aseptic (cleaved) oblique end to-end anastomosis after excision of carcinoma of pelvic colon A Placement of posterior row of sutures Three or 4 Halsted mattress

and the jejunum should lie free below it. Nevertheless, because of the nature of the entry of the blood vessels at the mesenteric border, with direct penetration of the circular muscle of the bowel wall, relatively small increases of intraluminal pressure may result in severe damage

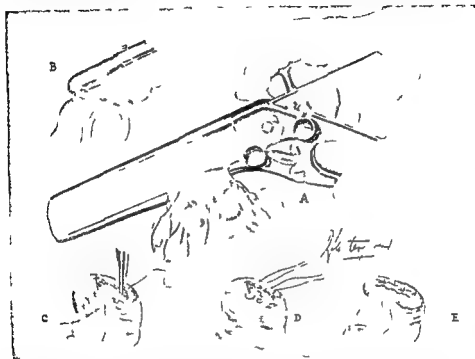


FIG 66—Use of v Petz (2) suturing apparatus in intestinal surgery. The instrument is shown here as employed in colonic resection with end-to-side anastomosis. General adoption of the oblique end-to-end anastomosis in all intestinal resections whenever feasible has made use of the v Petz instrument in intestinal surgery rather infrequent. The writer uses it regularly when practical however in closure of the duodenum much as is shown here. A Application of the instrument. B Cutting between the two parallel rows of metal clips deposited by turning the wheel of the instrument with the cautery. C Placement of the two semi-purse strings at either end. D Placement of the Halsted mattress sutures. E The inversion completed. The turning of the wheel in the right hand of the operator deposits a double row of clips. Engagement of the bowel in the instrument at its base suggests that a loop of gut was crushed previously for the first clips deposited by the turning of the wheel emerge at the tip of the instrument. (See Figs 62 and 99.)

have been rotated the double ferrule for the anterior anastomosis is in place as well as the holding device over the shank of the clamp. The first inner row—a running suture of catgut (000) has been placed. Note straight mosquito forceps to identify the posterior running suture and the curved mosquito forceps for the anterior. G The clamps have been withdrawn and the second or final and outer anterior row of interrupted Halsted mattress sutures has been placed. The writer employs the lateral anastomosis essentially only in entero-anastomoses. The oblique end-to-end anastomosis is a better and more physiologic operation for primary resection.

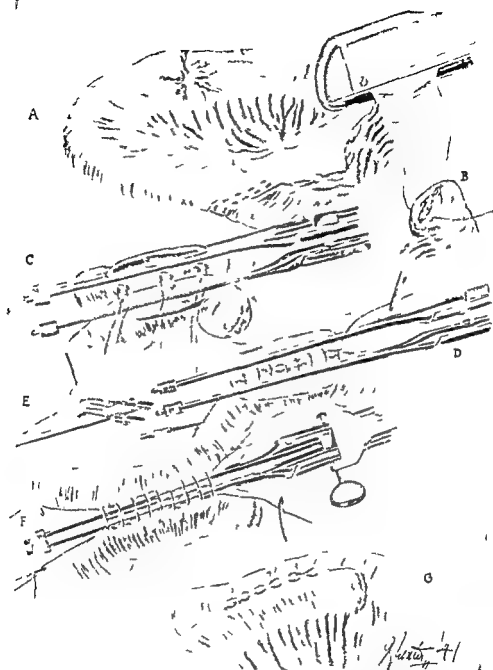


FIG 62—Technical steps in lateral anastomosis of the small intestine employing the v Petz suturing apparatus A Severance of the mesentery and application of the v Petz instrument B The inversion of the blind ends after severance with the cautery C The first posterior row of interrupted Halsted mattress sutures D The second or inner posterior row—a running suture of catgut (000) E Cutting the cuff of bowel above the clamp just before starting the anterior suture Because the blade of the aseptic anastomosis clamp is thin one must cut the cuff 1 to 2 millimeters above the clamp F The single ferrules have been knocked off (see Fig 57) the clamps

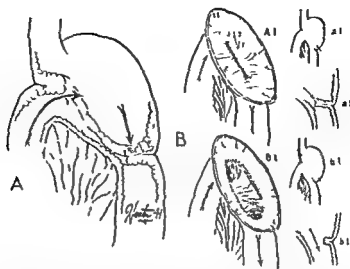


FIG. 66.—Mechanism of obstruction at the efferent outlet after gastrojejunal anastomoses. A Inversion of too much tissue creates a flap which obstructs at the efferent outlet. Obstruction at the afferent inlet through such an agency is distinctly unusual. B The gastrojejunal stoma after incorrect and correct suture. a 1 Oversuturing (incorrect) with narrow stomal slit and obstructing flap at efferent outlet. b 1 Wide stomal slit with large patulous stomas at inlet and outlet (correct) after inversion of 5 cm. of the adjacent gastric and jejunal walls in the anastomosis.

of the bowel wall. This greater susceptibility to injury of the duodenum over other segments of the bowel, attending increases in intraluminal tension has been described by C. A. Dragstedt and his associates (1929) and is depicted in Fig. 67. In the Billroth II type of gastric resection in which the duodenum is divided and inverted, and, even after gastrojejunostomy

Venous Obliteration

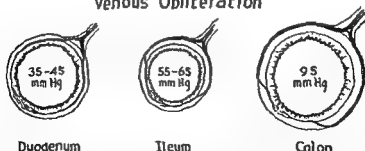


FIG. 67.—Venous obliteration attending intraluminal pressure at various levels in the bowel. Owing to the immediate penetration of the muscular coat by the vessels at the mesenteric border (5 and 7 o'clock) relatively small increases of intraluminal pressure will cause venous obliteration as contrasted with the colon where the entry of the vessels is at 1 and 11 o'clock. In the ileum the vessels enter at 3 and 9 o'clock (C. A. Dragstedt et al. Arch. Surg. 1929).

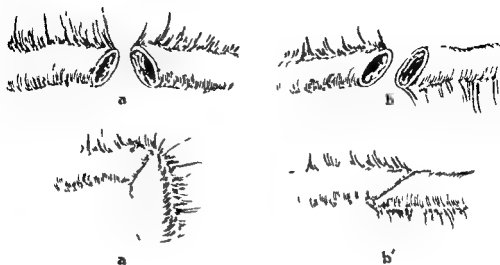
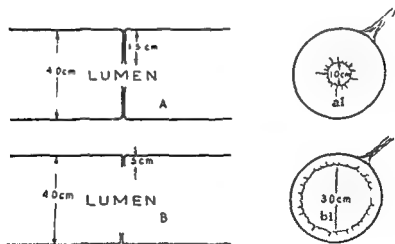


FIG 64—Reversal of mesentery of one segment of the bowel in oblique end to end anastomosis as suggested by Dennis (a) Shows the usual manner of dealing with the mesentery and the resultant angulation of the bowel in the dog (b) Dennis scheme of reversal of the mesentery. In the bowel of ordinary diameter there is probably little need to reverse the mesentery. In the terminal pelvic colon however the surgeon may find it useful in oblique end to end anastomoses (See also Fig 94)



End to End Anastomosis

FIG 65—The resultant stoma in end to end anastomosis A After inversion of a cuff of bowel 1.5 cm in width (overinversion with poor stoma) B After inversion of a cuff only 5 cm in width (satisfactory stoma) Inversion of more than $\frac{3}{4}$ cm should not be done

and Seley (1939) had administered solutions of sulphanimide subcutaneously to lessen the hazard of infection from operations upon the colon. Subsequently Ravdin and his associates (1940) employed this same expedient to lessen the risks of peritoneal infection, accompanying rupture of the vermiform appendix.

The superiority of local implantation of one of the sulfonamides about an operative site, in which potential peritoneal contamination has occurred, resides in this: that a considerably higher local concentration of the drug is achieved.

Because of the possibility of liver damage attending the use of sulphanimide, and especially because dangerously high blood levels may attend its use, we have come to rely largely in this clinic on the local implantation of sulfathiazole to reduce the hazards of peritoneal contamination. If sulphanimide is to be implanted intraperitoneally, certainly not more than a total of 4 grams and better 2 or 3 grams should not be exceeded. Sulfathiazole is a better and safer drug in this respect. The writer has on many occasions following primary colonic resections implanted 4 grams in the peritoneal cavity and an additional 2 grams in the incision, one gram being placed above the peritoneal closure beneath the muscles, and the other gram beneath the skin, overlying the fascial closure. On a few occasions, a total of 7 grams of sulfathiazole has been used. Blood levels of 2 to 5 milligrams per cent are usual after this dosage.

One of the great advantages attending local implantation of sulfathiazole over sulphanimide is that the absorption from the local area is slower. In consequence, a prolonged high local concentration results with considerably less risk of obtaining dangerous blood levels. As far as is known, sulfathiazole does not injure the liver, as does sulphanimide. However, both sulfathiazole and sulfapyridine are eliminated rather quickly in the urine and dosage adequate in amount to provoke a high blood level may cause plugging of the tubules—a danger to be borne constantly in mind. Sulfathiazole is superior to sulfapyridine for implantation in that local irritative effects do not attend its use. The subcutaneous use of sodium sulfathiazole to prevent urinary tract infection attending use of the indwelling urethral catheter will be described subsequently.

The local implantation of sulfathiazole about anastomoses performed in the presence of acute intestinal obstruction appears to be fully justified. However, it is to be emphasized the local use of the sulfonamides constitute, in no sense, a substitute for careful precise, aseptic procedures. Febrile reactions, giving rise to anxiety concerning the source of the fever, are provoked occasionally by sulfathiazole. It behooves anyone using the drug to lend vigilant notice to the urine output and the occurrence of fever during administration of sulfathiazole.

Hawking (1941) has determined, in guinea pigs, the local concentration and the rate of absorption following local implantation of the various sulfonamides. Whereas local implantation of crystalline sulphanimide gives high immediate concentrations because its rate of absorption is rapid, after 24 hours, the residual local concentration is slight. The local implantation of crystalline sulfapyridine is followed by local concen-

with high grade duodenal obstruction, the occurrence of obstruction at the afferent inlet of the gastrojejunal stoma is a potential disastrous occurrence. Whereas, obstruction at the efferent outlet of the gastrojejunal stoma may be well withstood, by a

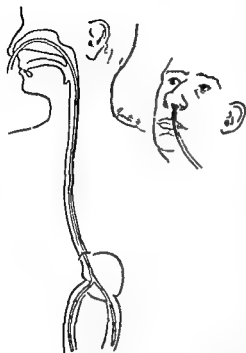


FIG 68—Forked catheter employed to prevent obstruction in the proximal jejunal loop after gastrojejunal anastomoses. One limb of the catheter is placed in the distal jejunal loop as well. Suction can be exerted simultaneously on the residual gastric pouch the afferent and efferent limbs. The tube is removed 72 hours after operation (Surg Gynec & Obst 72:257 1941)

the small residual gastric pouch has been employed regularly after gastrojejunal anastomoses in this clinic for about two years, and has proved eminently practical. The catheter is left in place for three days after operation, the patient being permitted to drink water as soon as he has awakened fully from the anesthetic.

E INTRAPERITONEAL IMPLANTATION OF SULFATHIAZOLE ABOUT ANASTOMOSES

The local implantation of the sulfonamides into wounds was instituted by Jensen, Johnsrud and Nelson of the Minneapolis General Hospital in 1939. They employed sulphanilamide in compound fractures and noted an astonishing diminution in the incidence of infection. Varco (1941) placed sulfanilamide about complicated gastrojejunal anastomoses in the dog, with considerable lowering of the operative risk. Previously, Garlock

was a good risk patient for comparatively long periods of time, with adequate water and electrolyte replacement, obstruction at the afferent inlet, under the conditions described above, results in a closed loop and potential strangulating obstruction. Owing to the secretory activities of liver, pancreas and duodenal and jejunal glands, great increases in intraluminal pressure occurs with loss of viability of the gut wall. Patients, in which this complication develops die of hyperthermia, within 36 to 72 hours after operation. Experimental reproduction of the syndrome has been done by Lynn, Hay, and Wangenstein (1941).

This potential complication of gastrojejunal anastomoses is little known. Fortunately, it does not occur often, but, when it does, the patient dies almost invariably. A means of insuring protection against this unfortunate contingency is shown in Fig 68. Such a forked catheter, which affords opportunity for exerting suction upon the afferent and efferent loops as well as

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trations of about 42 mg per cent, which persist for 7 to 10 days. Following local implantation of crystalline sulfathiazole, local concentrations of 104 mg per cent persisting for four days were noted.

In this clinic, no determinations of the local concentration of the sulfonamides have been made, other than those published initially by Jensen, Johnsrud and Nelson. Based on the work of Hawking, just described, and our own experience with the blood levels observed in patients after local implantation of sulfathiazole, it would appear that the latter drug satisfies nicely, the requirements of an effective and safe local bacteriostatic agent.

OF THE OPERATIVE RISKS OF THE CLOSED ANASTOMOSIS

The experience of this clinic with the closed anastomosis indicates that gastric resection for ulcer three quarter resection, excising 75 per cent of gastric tissue, including its complications, other than perforation, may be done with a mortality of 2 to 3 per cent. Gastric resection for malignancy (80 to 100 per cent excision of gastric tissue) carries a mortality of approximately 10 per cent. The difference in operative risk is made up largely by the greater physical infirmities of increased years. Primary resection of nonperforated malignant lesions in the colon carries an operative hazard of about 5 per cent. Preliminary colostomies are made only in patients who come with obstruction. Whether a patient has had a preliminary colostomy does not appear to affect the issue materially.

The operative risks of the closed anastomosis, in dealing with the bowel obstruction problem, are a little more difficult to declare. First, one would not, by choice, make a primary anastomosis in the colon, in the presence of obstruction. Muschkat is one of the few who advise it for volvulus of the sigmoid flexure (see page 392). Yet as indicated above, in the chapter on choice of operative procedure, in obstructions of the small bowel brought about by malignant lesions the present policy, in this clinic, is to perform primary resection, wherever feasible. Similarly, with strangulating obstructions, in the small intestine, primary resection with oblique end to end anastomosis is considered to be the operation of choice. Yet, in any clinic during the interval of a year's time relatively few such cases, demanding excision of the bowel during the presence of acute obstruction are seen. During the past year 11 such primary resections were done in this clinic by Dr. Clarence Dennis and the senior surgical house officers. There were no deaths. However, it is to be admitted freely that in a large group of cases, the factors of strangulation including its threats of impaired viability of the bowel wall and blood loss, and distension with its difficult problems—the elements involve risks, at least in the light of present experience, considerably greater than those listed above in operations of election upon the gastrointestinal canal. Certain it is the risks of primary resection for strangulating obstruction, are so far better than any other method of dealing with this type of obstruction that the practice of protracted efforts at achieving decompression by conservative means in patients who may have strangulating obstruction, should be discontinued.

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trations of about 42 mg per cent, which persist for 7 to 10 days. Following local implantation of crystalline sulfathiazole, local concentrations of 104 mg per cent persisting for four days were noted.

In this clinic, no determinations of the local concentration of the sulfonamides have been made, other than those published initially by Jensen, Johnsrud and Nelson. Based on the work of Hawking just described, and our own experience with the blood levels observed in patients after local implantation of sulfathiazole, it would appear that the latter drug satisfies nicely, the requirements of an effective and safe local bacteriostatic agent.

F THE OPERATIVE RISKS OF THE CLOSED ANASTOMOSIS

The experience of this clinic with the closed anastomosis indicates that gastric resection for ulcer three quarter resection, excising 75 per cent of gastric tissue, including its complications, other than perforation may be done with a mortality of 2 to 3 per cent. Gastric resection for malignancy (80 to 100 per cent excision of gastric tissue) carries a mortality of approximately 10 per cent. The difference in operative risk is made up largely by the greater physical infirmities of increased years. Primary resection of nonperforated malignant lesions in the colon carries an operative hazard of about 5 per cent. Preliminary colotomies are made only in patients who come with obstruction. Whether a patient has had a preliminary colostomy does not appear to affect the issue materially.

The operative risks of the closed anastomosis, in dealing with the bowel obstruction problem, are a little more difficult to declare. First, one would not by choice, make a primary anastomosis in the colon, in the presence of obstruction. Muschkatian is one of the few who advise it for volvulus of the sigmoid flexure (see page 392). Yet as indicated above, in the chapter on choice of operative procedure, in obstructions of the small bowel brought about by malignant lesions the present policy, in this clinic, is to perform primary resection, wherever feasible. Similarly, with strangulating obstructions, in the small intestine, primary resection with oblique end to end anastomosis is considered to be the operation of choice. Yet, in any clinic during the interval of a year's time, relatively few such cases, demanding excision of the bowel during the presence of acute obstruction are seen. During the past year, 8 such primary resections were done in this clinic by Dr. Clarence Dennis and the senior surgical house officers. There were no deaths. However, it is to be admitted freely that in a large group of cases the factors of strangulation including its threats of impaired viability of the bowel wall and blood loss and distension with its difficult problems—these items involve risks at least in the light of present experience considerably greater than those listed above in operations of election upon the gastro intestinal canal. Certain it is the risks of primary resection for strangulating obstruction, are so far better than any other method of dealing with this type of obstruction that the practice of protracted efforts at achieving decompression by conservative means in patients, who may have strangulating obstruction, should be discontinued.

CHAPTER IX

POSTOPERATIVE TREATMENT

A CARE ON COMPLETION OF OPERATION

POSTOPERATIVE treatment begins when the dressings have been applied on completion of the operation. In this clinic inhalation anesthesia, ordinarily intratracheal cyclopropane is the anesthetic agent which enjoys widest use. The first concern of the surgeon, after the operation is finished is that the pharynx of the patient is dry. To this end, during the latter part of the operation (abdominal closure) the anesthetist tilts the head

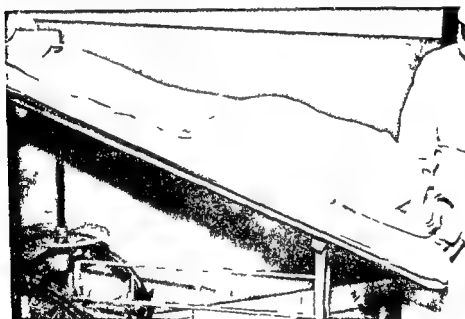


FIG 69—Mode of transfer of patients who have undergone long and difficult operations from the operating room. The interne is supporting the patient's jaw and the patient is on his side in the Trendelenburg posture.

of the table downward into a moderately steep Trendelenburg position to facilitate gravitation of tracheal fluid or mucus into the pharynx. The pharynx is aspirated with a urethral catheter until the patient is quite dry. During operation the anesthetist aspirates through the intratracheal tube as frequently as is necessary.

When the patient is placed on the litter for transport to his room, he should be placed on his side to avoid posterior displacement of the tongue into the pharynx which accident is more likely to occur in an unconscious patient transported in the supine position. If the operation has been long

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meters of mercury as indicative of the presence of threatening shock and to treat the patient accordingly. In the experience of the writer, the gravity method of transfusion of citrated blood is the most convenient. Save for the depression of arterial pressure attending the use of spinal anesthesia there are few indications for employment of vasospastic agents, such as adrenalin or ephedrine in the treatment of shock.

In this clinic it is routine practice to insert a needle into one of the ankle veins of the patient, having major abdominal surgery, on the operat

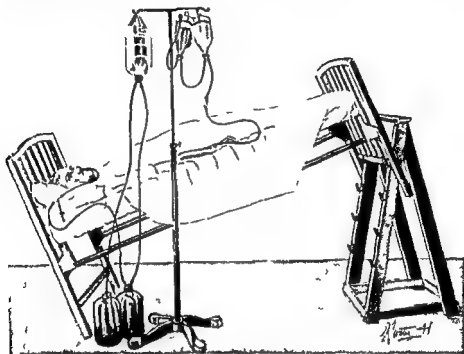


FIG 70—Use of shock frame in recovery period (see text) Note insertion of needle into vein on dorsal aspect of forearm permitting free motion of patient's forearm (see text) The three bottle suction apparatus is shown also The catheter is anchored to the upper lip with adhesive tape

ing table just before commencement of the operation. Saline solution is allowed to run in very slowly. If the operation is long and tedious, if blood loss is of such an order as to warrant blood replacement or if the patient's condition suggests the need for it, a transfusion of blood or plasma is given through this ankle vein needle during the course of the operation. With this practice startling surprises in the appearance of shock in patients prepared adequately for operation on return to the ward are very unusual. The anesthetist's record indicates how much fluid, plasma or blood the patient was given in the operating room.

To be certain, every patient operated upon need not be transfused. Yet the blood loss in operations, in the main even amongst surgeons

and tedious, or, if the blood pressure hovers around the shock level of 100 mm Hg or less, the patient should be transported in the head down position (Fig 69). No patient in shock should leave the operating room until the shock has been treated adequately. It is a mistake to hurry the patient out if shock is present or impending. Two attendants should accompany the patient from the operating suite to his room.

B CARE OF THE PATIENT ON ARRIVAL AT THE WARD

Every anesthetized patient who has had a major surgical procedure on the surgical service of the University Clinic is placed on a shock frame as indicated in Fig 70. This position gives assurance on two points: 1. Any secretions in the trachea or larynx will gravitate to the pharynx from which point of vantage, they may be aspirated more readily. 2. The blood pressure is supported satisfactorily.

Every anesthetized patient must have the constant and undivided attention of a nurse until the patient is awake and fully oriented. During this period, the suction apparatus is attached again to the indwelling duodenal tube. All patients who undergo abdominal surgery of a major character by the writer have an indwelling duodenal tube inserted into the stomach an hour or two prior to operation. Suction is in force *before* operation, *during* operation and *uninterruptedly* during the first few days of the recovery period. The only time, during which suction is not in force, is the few minutes occupied by the transport of the patient from the operating suite to his room. The constant application of suction insures an empty stomach and when combined with a judicious use of the Trendelenburg position, affords the best protection against the development of post-operative pneumonia. Aspiration into the lungs is, without doubt, the most important cause of pneumonia after operation.

C SHOCK

The immediate concern following operation is that the patient is returned to his bed with evidence of satisfactory status of the circulation. If the systolic blood pressure is less than 100 millimeters of mercury and the fluid administration has been liberal, the foot of the bed should be elevated on a shock frame (Fig 70). Whereas it has been alleged (Cannon 1923) that this expedient has no virtue in the treatment of shock, trial will demonstrate that the rationalizations which proved it ineffective were based on false premises. Its frequent use after potential shock-producing operations, as an extensive thoracoplasty, has decreased the necessity of combatting shock by more energetic agents such as transfusion of blood or plasma. If the systolic blood pressure is not sustained above 100 millimeters of mercury, elevation of the foot of the bed on a shock frame, intravenous infusion of a crystalloid solution (5 per cent glucose in distilled water or saline solution), and transfusion of blood or plasma should be successively tried. It is not wise to permit the systolic blood pressure to remain far below the normal level for long. Eighty millimeters of mercury is usually considered to be the critical level of blood pressure; the writer prefers to consider a systolic pressure of less than 100 milli-

who is awakening from the effects of an inhalation anesthetic, frequently has a good deal of mucus in his mouth and pharynx probably as a result of irritation of the tracheal and bronchial epithelium. The danger of aspiration asphyxia, in such a patient who has not yet regained his cough reflexes is real, if he is returned to bed with his head higher than his trunk.

The Fowler or semi Fowler position is much overused by surgeons generally. Probably the only indication for its use in abdominal cases is when one hopes to influence the site of collection of exudate in an intra peritoneal abscess by the force of gravity. In the main, in the early post operative period, the low position of the head is the best. When it is definitely known that shock will not develop and the patient has fully recovered from the effects of the anesthetic, the shock frame can be lowered from beneath the foot of the bed. Until the patient becomes active, usually three or four days after operation, it is a good plan to keep the foot of the bed on the lowest rung of the shock frame or on low props, in order to insure an unobstructed flow of blood from the lower extremities. The writer prefers to have the patient lie with the head on one pillow with the bed horizontal well into the recovery period, sitting up in bed only for meals.

Frequent postoperative change of posture has superseded routine employment of Fowler's position as being more acceptable. Every two hours day and night, except when the patient is asleep, his position in bed is changed by attendants in the following manner: he lies two hours on his back, then two hours on one side, then two hours on his back again, followed by two hours on the other side, and so on. In this clinic, unless there be some strict contraindication directly after operation every patient is urged to move his arms and legs freely, "a thousand times a day" — an admonition which is pressed on him until he becomes ambulant. This exhortation is repeated to him by nurses and interns so that he is kept mindful of the counsel. These injunctions relate to patients, who have been operated upon for bowel obstruction with equal force, as they do to other intra abdominal conditions.

E PULMONARY ATELECTASIS

When the peritoneal cavity is opened some very interesting physiologic phenomena occur in consequence. One of these is the inhibition of movement of the diaphragm. This happening has been much investigated, but what causes it has not been determined. It would appear to be a reflex phenomenon and apparently sets in as soon as the pain sense returns (Carlson 1932). This circumstance undoubtedly relates itself intimately to the occurrence of pulmonary atelectasis. This impaired mobility of the diaphragm is more apparent following upper abdominal operations than after lower and lasts well into the convalescent period. Any stimulus to respiration such as the periodic inhalation of carbon dioxide will affect this inhibition favorably but only as long as respiration is thus artificially stimulated. The value of hyperventilation with carbon dioxide in obviating this constant accompaniment of abdominal operations has undoubtedly been overrated. The writer prefers to have the patients cough two or

who practice the strictest hemostasis, is greater than is appreciated generally. Gatch and Little (1924), Maddock and Collier (1937) and White and his associates (1938) have measured the blood loss in various types of operations. Their findings substantiate this statement. Transfusion is not to be employed as a substitute for careful hemostasis.

In patients, who come to the clinic with a high grade anemia and who present a formidable surgical problem in the excision of their tumor or the correction of their surgical lesion, a number of transfusions are often necessary. Following the suggestion of DeGowin and Hardin (1940, 1941), in patients needing multiple transfusions of blood, it has become routine practice, in this clinic, to give such patients a liberal supply of sodium bicarbonate by mouth (10-15 grams) or a 5 per cent solution intravenously (250 cc) daily to insure an alkaline urine. It is DeGowin's contention that albuminous casts in the renal tubules are much less likely to form attending hemolytic reactions if the urine is alkaline. Though such reactions are infrequent, they are unfortunately followed by oliguria and often, fatal anuria. A number of such reactions, accompanied by fatal anuria have occurred in transfusions involving group 'O' donors and recipients. Witelsky and his associates (1941) have described recently addition of A and B substances to the transfused blood to remove A and B and Rh agglutinins. Such an aid, if proved practical, would be a great boon to surgery.

In the experience of the writer, such plugging of the renal tubules with albuminous casts, as a consequence of transfusions has been observed more frequently in anesthetized patients transfused with stored blood during or immediately after operation. Whether anesthesia per se may contribute to its occurrence is not known. Nevertheless, the writer is inclined not to employ the blood from more than one donor during or immediately after operation. By preference therefore, such patients are given plasma, if blood loss replacement is indicated. If colloidal infusions beyond the amounts of plasma available are required, a single transfusion of blood is given. Under unusual circumstances, of course it becomes necessary, occasionally, to set aside this guiding rule in the interests of supporting a falling blood pressure, by giving blood from more than one donor.

It is a task of some magnitude to impose responsibility on a hospital staff, for providing enough available plasma from blood donors to carry patients needing formidable operations through their hospital stay. Yet, this effort is justified fully in the avoidance of hemolytic transfusion reactions and their consequences.

The search for a satisfactory blood substitute which will be readily available for treating shock is very much worthwhile. Bovine albumin, or some other suitable substitute for human blood or plasma, may some day fill that much needed want.

D POSITION IN BED

The position of the patient in bed is important. A patient, who has not fully regained consciousness, must be placed with his head lower than his body trunk, to prevent aspiration of saliva into the lungs. A patient,

is extremely important (Fig 72) The status of chlorination of the patient can be determined by rules outlined previously Average amounts of sodium chloride lost in gastroduodenal aspirations average about 5 grams per liter and for perspiration about 11 grams per liter (Coller and Mad dock) Minimal quantities of salt are lost in the insensible perspiration Determination of the fluid losses the daily excretion of sodium chloride in the urine and an occasional plasma chloride determination, when and

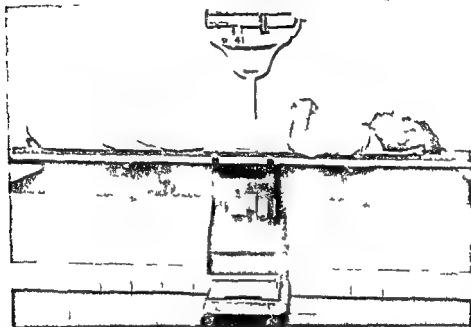


FIG 71—Manner of obtaining bedside weights of patients after operation The block on the scale supports the stretcher Significant gains or losses in weight may be detected readily The weighing of patients before and after operation has come to be an important item in determining the status of hydration in this clinic (Surg Gynec & Obst 72 257 1941 Feb 2A)

where needed will give excellent orientation concerning the sodium chloride balance Excesses of sodium chloride should not be given lest edema occur There is a definite lag in the excretion of excessive amounts of sodium chloride and in the patient with poor cardiac reserve such sodium chloride retention with consequent water retention may invite pulmonary edema and other undesirable sequelae

Water Requirements

If the patient presents a normal state of hydration prior to operation, postoperative weighing of the patient is an excellent guide to maintenance of an approximately normal fluid balance (Fig 71) For patients undergoing operations of election this is an excellent expedient and one that extensive trial, in the University of Minnesota Surgical Clinic has demon

three times following a deep inspiration, while the nurse compresses the lower chest and abdomen, thus protecting the incision with the avoidance of pain. This maneuver is repeated many times each day during the early recovery period.

With opening of the peritoneum, a temporary cessation of intestinal movement occurs. This circumstance may be observed also in drainage through an enterostomy opening made for the relief of mechanical obstruction during the early postoperative period. This phenomenon of impaired motility of the gut gives rise to distension with its accompanying sequelae. It is difficult at times to escape the impression that a patient after operation may not swallow more air than he otherwise does. Definite proof of this, however, is lacking. It has been related already how a dog with a transected cervical esophagus will swallow a good deal of air unless the distal end is turned in (p. 17). Whereas ordinarily air is brought into the stomach only in deglutition, apparently such an animal may swallow air coincidental with respiration. Determination of pressures in the esophagus of a few such animals showed that subatmospheric pressures were often present. It is altogether possible, of course, that the sphincters of the esophagus in postoperative patients may so behave as to permit abnormal entry of air into the stomach. Suction applied to an indwelling duodenal tube is the best means of mitigating the effects of paresis of the bowel associated with intraperitoneal operations.

F PREVENTION OF THROMBOSIS

Another consequence related to the two preceding items, viz., inhibition of diaphragmatic motion and paresis of the gut, is the slowed circulation in the lower extremities. Keeping the foot of the bed elevated and urging active motion on the patient serve to prevent stagnation of blood in the veins of the lower extremities. Intestinal distension impedes the venous return from the lower extremities too (Bellis and Wangenstein 1939). It is not unlikely, therefore, that these two same occurrences may be related fairly directly to the problem of postoperative thrombosis and embolism. The more frequent occurrence of embolism after abdominal operations than after others is well known. In the instance of the prostate, this circumstance is best shown. The suprapubic method of prostatectomy with an abdominal but extraperitoneal incision is followed by a greater incidence of embolism than attends the perineal or intravesical methods of removal. The latter two methods of approach are not often attended by inhibition of diaphragmatic motion and meteorism.

The frequent change of posture and assumption of active movement aid in accelerating the venous return from the lower extremity as probably does also the prevention of intestinal distension.

G THE POSTOPERATIVE ADMINISTRATION OF FLUID

Sodium Chloride Needs

The guiding rules formulated on page 132 are applicable here. The daily careful summation of fluid intake, urine output, and other fluid losses

fluids administered subcutaneously are given on the external aspect of the thigh, beneath the fascia lata

For the administration of concentrated solutions of glucose (20 per cent) described below, as well as for infusions of blood, plasma and amino acids, the intravenous route must of course be used. The too rapid infusion of high concentrations of glucose solution results not alone in the loss of glucose in the urine but in a loss of interstitial fluid with dehydration as well (Keith 1929). Ordinarily 3000 to 4000 cubic centimeters of paroral fluids a day (be it given slowly by the intravenous route in a morning and evening administration) suffice. If there be any doubt about the status of hydration an accurate check of the hemoglobin, together with determination of the specific gravity of the plasma especially if preoperative values are available, affords reliable information concerning the fluid requirements of the patient. With employment of suction patients may be permitted water by mouth directly after operation. The mouth should be kept moist and clean to preclude the occurrence of parotitis.

II MAINTENANCE OF CALORIC AND NITROGEN BALANCE

For many years now surgeons have been alert to the water and electrolyte requirements of patients undergoing operation. Apart from giving enough glucose to avoid the ketosis of starvation little interest has been taken by surgeons in the general problem of meeting the caloric requirements of the patient. And practically no notice has been given the item of maintaining the patient in nitrogen equilibrium. In a sense physiological teachings have been responsible for this neglect on the part of surgeons. Medical students are being reminded constantly how long men have gone without intake of food. Most men undergoing such trial periods of starvation however come to the ordeal well prepared in a good state of health. Patients frequently come to the surgeon after long periods of starvation and undergo at his hands procedures involving great risks which test crucially the capacity of the body to withstand operative trauma with no further preparation than to make certain that severe anemia is not present and that the water and electrolyte requirements are met. In addition to the uncompensated preoperative starvation and the trials of operation such a patient must bear too the burden of starvation enforced by the recovery period.

This practice obviously is wrong and should be discontinued. A maximal effort should be made by the surgeon to bring his patient into caloric and nitrogen equilibrium before operation is undertaken. Poor risk patients who exhibit great weight loss from obstruction at the gastric outlet present the most difficult type of problem. The intestinal canal cannot without the performance of a preliminary enterotomy be used for purposes of feeding. Inasmuch as no ideal enterostomy feeding mixture is available and because enterostomy alone for such patient is sometimes a difficult burden it has been the practice of this clinic to prepare such patients for operation by intravenous feeding.

Whipple and his associates have demonstrated that a dog may be main

strated to be superior, at least in our hands, to all other methods in avoiding large fluctuations in weight and in approximating the normal status of hydration. An ordinary bedside scale, equipped with a block to hold a litter carrier, answers the purpose adequately. Experienced nurses will weigh patients on such a scale to an accuracy of about 100 grams. It is weight disparities, beyond 1 to 2 kilos, in the adult of average weight, that concern us. Every patient undergoing surgery of a major character, at the hands of the writer, is weighed, several times before operation (whenever possible) and daily, each morning after operation. When the patient supports himself on an oral intake and meets his fluid requirements by satisfying his own thirst, weighing is no longer necessary.

In obstructed patients, whose status of hydration may have been far from normal on admission, weighing is not of so much value. The excretion of 800 to 1000 cc. of urine daily suggests that the fluid requirements of the patient have been met. The amounts of fluid necessary to meet the requirements of patients have been discussed previously (page 133). It is to be remembered that anesthesia has a profound effect upon vaporization of fluid from the skin. The surface capillaries of the skin are dilated with increased fluid loss. Inhalation anesthesia affects all the surface capillaries in this manner. Spinal anesthesia causes increased loss of fluid only from the anesthetized surface areas.

It may be necessary to determine the hemoglobin and compare the reading with preoperative values to determine whether hemoconcentration or dilution has occurred. Periodic determination of the plasma proteins by the falling drop according to the method of Barbour and Hamilton (1927) gives added information concerning the status of hydration. In this hospital standards made up by Bellis have been employed to determine the specific gravity of the plasma.

The Kind of Fluid

For the usual patient with obstruction, 3000 to 4000 cc. of para-oral fluids suffice. Patients presenting obvious evidences of dehydration need more (see page 133). Once the losses of sodium chloride sustained by vomiting have been replenished unless the gastroduodenal aspirations are great, 4 to 9 grams of sodium chloride will meet the situation adequately. If more than 3 grams are excreted daily in the urine even this amount (9 grams) is too much. The remainder of the fluid is to be made up by varying concentrations of glucose in distilled water.

Routes for Administration of Fluid

After abdominal operations of a major character, only the subcutaneous and the intravenous routes are to be depended upon for the administration of fluid. In the main, unless the rate of flow is adjusted carefully, it is better to give saline solution or 5 per cent solutions of glucose under the skin. The too rapid intravenous administration of fluid is hazardous, especially in poor risk patients. Yet, in dehydrated patient the intravenous route is to be preferred to subcutaneous administration. In this clinic, all

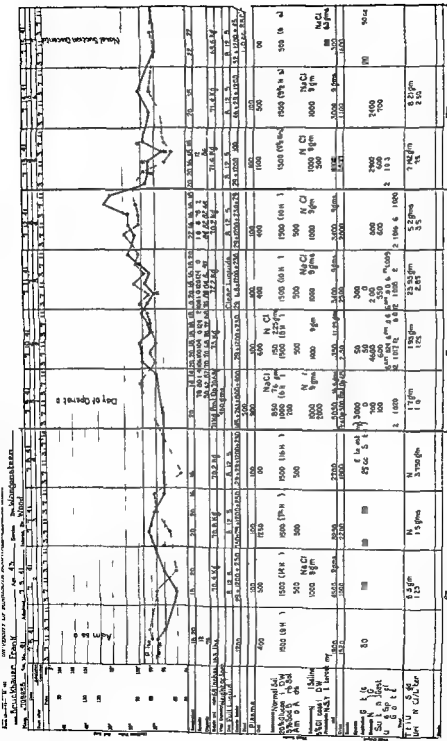


Fig 72.—Photograph of hospital record indicating the mode of pre and postoperative management. The patient had total gastrectomy for cancer. Nitrogen balance was maintained by the intravenous administration of amino acids supplemented by plasma and 1500 ml of 20% glucose solution was given daily. The febrile response on the 4th postoperative day followed intravenous administration of amino acids. The patient was dismissed 12 days after operation.

tained in nitrogen equilibrium by the intravenous administration of canine plasma, without exogenous food intake. In this clinic, similar observations have been made on man with human plasma. It has been shown, too, that bovine plasma may be given to man and that nitrogen equilibrium may be maintained through such an agency. It is to be admitted freely, however, that the administration of bovine plasma to man is still an experimental venture, even though amounts in excess of 2500 cc have been given to more than 150 patients in this clinic. Bovine albumin (Cohn) appears to have more promise.

Ravdin and his associates have stressed the great value of simultaneous feedings of adequate amounts of protein and carbohydrate in maintaining normal glycogen stores in the liver, and in replenishing them after periods of starvation. They have shown, also, that oral feeding is more effective, in this respect, than is intravenous feeding.

Intravenous Administration of Nitrogen

It is doubtful whether nitrogen equilibrium may be maintained by the administration of amino acids, now commercially available. Whipple and his associates have shown, however, that addition of small amounts of methionine and tryptophane to one of the amino acid solutions, prepared from a casein digest will maintain nitrogen balance. The work of Roe, Elman and Whipple and their associates has done a great deal to develop a practical way of maintaining nitrogen equilibrium in surgical patients. The addition of methionine and tryptophane makes of the amino acid mixture, a fairly complete protein and supplies the missing essential amino acids. The casein, from which the amino acids are prepared by a combination of enzymatic digestion and acid hydrolysis, is a complete protein, but some of the essential amino acids are lost apparently in the manufacture of the digest. Plasma, being a complete protein, constitutes a satisfactory source for the maintenance of nitrogen balance, on intravenous administration.

A patient receiving a protein sparer (glucose in adequate amounts), can be maintained in nitrogen equilibrium on a relatively small nitrogen intake. Five to six hundred cc of plasma will suffice. It is debatable, however, whether it would be wise to give a patient that amount of plasma intravenously, each day, lest the injection of this colloidal fluid might increase the blood volume and invite heart failure, in patients with poor cardiac reserve. It has been our practice to give, daily, 500 cc or more of one of the commercially available amino acids (Stearns nitrogen content 2.4 grams per cent, Mead Johnson 16). This amount of nitrogen will approximate maintenance of nitrogen equilibrium, when supplemented with 200 cc of human plasma given in 100 cc amounts twice a day. This scheme has proved eminently practical and a large number of poor risk patients have been prepared for operation in this manner. In order to initiate the storage of protein in the liver, however it is obviously necessary to give more than enough nitrogen to meet the energy requirements of the patient. Plasma meets this latter requirement best in that the urinary excretion of nitrogen is not augmented by the intravenous injection of plasma, as attends the intravenous injection of amino acids—the protein of injected plasma being available for purposes of increasing the depleted stores of de-

the operative attack be a direct one in which the obstructive mechanism is undone, or indirect, in which external drainage is accomplished by enterostomy, because of the paresis of the bowel incident to operation, suction should be continued well into the convalescent period in every obstruction. It is the writer's practice to employ suction routinely after all operations for obstruction—even after surgical relief of acute obstruction of the colon in which the small intestine does not participate in the distension. The exertion of continuous suction upon an indwelling catheter in such instances prevents prophylactically the occurrence of general intestinal distension incident to operation. In infants, suction should not be long continued into the postoperative period without interruption because of the danger of otitis media owing to the presence of the tube in the pharynx. As the quantity of gas and fluid returned by the siphonage diminishes, suction may be interrupted by intermittently clamping the tube and when discontinuance of suction, over a three or four hour interval causes no distress the tube may be removed. It has been the writer's practice also to apply suction to an enterostomy tube largely so that the gas and fluid returns may be accurately measured. In the main, it may be said that the amounts aspirated through the duodenal tube are usually considerably greater in amount only in the presence of high grade obstructions does the postoperative drainage through an enterostomy catheter approach the aspirations made simultaneously through the indwelling duodenal tube. The indication for removal of an enterostomy tube is ability on the part of the patient to tolerate it being clamped without occasioning him distress. The writer's usual practice is to keep the tube in situ until the patient becomes ambulant, about the tenth or twelfth day. A valvular enterostomy well made will not leak on withdrawal of the tube.

J BOWELS

The employment of suction well into the convalescent period has practically done away with the need for enemas to obtain relief from distension. After abdominal operations of diverse natures in which this expedient is employed during convalescence, patients not infrequently go five to seven days without a bowel movement and without distress so similarly after operations for the relief of mechanical obstructions. An enema may be given at the end of this period or mineral oil may be permitted by mouth. Enemas during the early postoperative period should be discouraged. They are usually ineffectual and may do harm. Pituitary extract or other stimulants of intestinal activity, such as physostigmine or pilocarpine have been employed rarely by the writer. Undoubtedly there are isolated instances during the postoperative period when distension may be more effectually combatted by their use. The writer however inclines strongly to the passive treatment of distension as opposed to the active means of enhancing intestinal contractions. One of the best and probably the safest means of stimulating a distended bowel is to decompress it.

K AVOIDANCE OF PULMONARY COMPLICATIONS

Prevention of regurgitation of gastric content or aspiration of mucus or saliva into the lungs is undoubtedly, the most important factor in the

The plasma protein values are not depreciated significantly in some patients who come with a moderately long history of starvation. Moreover, it is far more important to learn, from the patient himself, that three or four weeks have elapsed, during which time, there has been almost absolute starvation with a long period of relative starvation preceding.

Intravenous Administration of Glucose to Maintain Caloric Balance

For a period of approximately two years, a 20 per cent solution of glucose has been given intravenously, in an effort to maintain caloric balance in patients with obstructions in the gastro intestinal canal—largely, patients with obstructed stomachs. If a 22 gauge needle is employed in a forearm vein as shown in Fig 71, the patient is allowed full range of motion, and, the rate of flow may be adjusted in such a manner that only 100 to 150 cc of the solution runs in per hour. It is not difficult to provide a patient with 1500 cc of a 20 per cent solution of glucose in this manner each day, over a short period of time. Daily quantitative determination of the amount of glucose spilled in the urine affords an accurate check of utilization. The serious drawback to the protracted use of a concentrated glucose solution in this manner is that, the veins become thrombosed. In addition local swelling accompanied by slight pain, occurs now and then. Yet, employing a combination of 20 per cent glucose solution and amino acids and plasma as outlined above, a number of poor risk patients have been prepared for operation and carried successfully through the recovery period after operation by this means until they can eat. Such patients gain in weight and strength and exhibit other discernible effects of improved health, while being prepared for operation on this regimen.

After gastric operations Ravdin and his associates have employed jejunal feedings, introduced through an inlying two way duodenal tube suction being applied to that portion of the tube lying within the stomach. The writer prefers to keep the upper reaches of the intestinal canal empty and finds intravenous feedings as outlined above very satisfactory. Intestinal paresis incident to operation impairs intestinal transport. Keeping the upper reaches of the gastro intestinal canal empty during the first few days of the recovery period is, without question, an important item in the prevention of pneumonia. It has been our practice to withdraw the forked indwelling duodenal tube, employed for purposes of expressing suction on the residual stomach, afferent and efferent limbs of the gastro jejunal anastomosis 72 hours after operation. The patient must then continue to have his oral intake complemented, in part by intravenous feedings, until the oral intake is adequate to support a satisfactory nitrogen and caloric balance.

Search for another satisfactory agent by which caloric balance may be maintained, by intravenous injection without inviting thrombosis is laudable. No evidence has been noted that slow intravenous injection as indicated above, favors the occurrence of heart failure.

I DISTENSION

Suction is the most effective agency in combating distension. Even when a mechanical obstruction has been relieved by operation whether

Hiccups, though inexplicable in many situations is essentially an irritative phenomenon involving the diaphragm and is most likely to present itself in situations which involve peritoneal irritation. In the Whipple operation for excision of the head of the pancreas for carcinoma—an operation which involves usually some leakage of pancreatic juice into the peritoneal cavity, persistent hiccuping has been a rather frequent complication. Now and then, firm pressure over the transverse process of the sixth cervical vertebra, with the patient's head turned appropriately to



FIG 73—Use of the Boothby Lovelace mask for the administration of high concentrations of oxygen. The intubating duodenal tube goes through the mask.

the side will compress the phrenic nerve and arrest hiccups. In the most persistent cases the treatment which has been found to be most effectual in this clinic is to inject one of the phrenic nerves with 1 per cent novocaine employing 30 to 60 cc. If hiccups return after a few hours the other phrenic nerve is injected similarly. After a few trials one learns which phrenic nerve is influenced most favorably by the injections. This information can not be gotten if both nerves are injected at the same time. Repeated subcutaneous injections of novocaine into the immediate vicinity of that phrenic nerve apparently influenced most by the irritative process constitutes the most effective way of arresting hiccups. In this clinic over a period of years, only one patient has had to have cervical crushing of one phrenic nerve to stop persistent hiccuping. Injections of novocaine controlled the hiccups effectually in that patient, but the necessity of frequent repetition of the injections suggested phrenic crushing as a more satisfactory therapeutic expedient.

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prevention of pneumonia The avoidance of pulmonary edema, by the too rapid intravenous administration of fluid or administration of too much fluid by any route, constitutes prophylaxis against the development of pneumonia Aspiration of the pharynx and larynx and stomach well into the operative recovery period, turning the patient frequently, and, enjoining on him the necessity of active motion are all important items in preventing pulmonary congestion

Despite all these measures, pneumonia still occurs Yet, now with sulfathiazole and sulfapyridine, the risks of pneumonia have been reduced considerably Both these drugs, if present in the blood stream in sufficient concentration, may cause plugging of the renal tubules Employment of large intravenous doses are, therefore, to be avoided In this clinic, the administration of sodium sulfathiazole in sufficient amounts by the subcutaneous route (1 gram per 125 cc of saline solution) to maintain a blood level of 5 to 6 milligrams per cent is the method of choice Four to six grams daily suffice usually Dramatic improvement attends often its use, in this manner Dr W W Spink, Associate Professor of Medicine, has afforded us great help by his counsel and writings in the management of postoperative patients with pneumonia Sulfathiazole and sulfapyridine, unlike sulphanilamide hold out no serious threat of causing liver damage It is to be remembered that sulfathiazole may provoke fever occasionally

An antecedent of pneumonia following many abdominal operations is undoubtedly, pulmonary atelectasis related to the temporary impairment of diaphragmatic excursion described above There are probably interphases in which the administration of one of the effective sulfonamides may thwart development of pneumonia from such a source

L RETENTION OF URINE

Most patients will void without great effort after operation Inability to void in the early postoperative period is considerably more frequent attending employment of spinal anesthesia Catheterization is in order when the patient is in distress and can not void spontaneously

In operations of some magnitude, the writer has come to insert a urethral catheter as a matter of routine Accurate determination of the daily urine output is attainable in this manner, the urine bottle being changed each morning at precisely the same hour The daily administration of two grams of sodium sulfathiazole subcutaneously in saline solution (twice daily in one gram amounts in 150 cc of saline solution) will suffice to avoid urinary tract infection from the indwelling catheter

M HICCUP

The indwelling duodenal tube is ordinarily the best prophylaxis against hiccups Yet, patients may develop hiccup with a tube in place functioning properly Abolishing this troublesome postoperative complication is often a trial and error process in which one tries the lesser remedies first, reserving the more aggressive therapeutic agents for the more refractory cases Adequate sedation in many instances is helpful Inhalation of high concentrations of oxygen, employing a Boothby or Emler mask has proved extremely helpful in many trying cases

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TABLE XXV—MORTALITY OF ACUTE INTESTINAL OBSTRUCTION

Author	Year of Report	Number of Cases	Mortality (Per Cent)
Scudder	1907	121	60
McGlannan	1913	181	37
Deaver and Ross	1915	276	42
Codman	1920	41	34
Richardson	1920	118	41
Flint	1921	283	15.6
Braun Wortmann	1924	379	39
Scuttar	1925	3064	26
Tuttle	1925	150	50
Holden	1926	135	19.2
Brill	1929	124	36
Miller	1929	343	61
Smithies	1930	56	41
Cornell	1932	235	51
Melver	1932	156	44
Vick	1932	6392	26
Vidgoff	1932	266	46
<i>The Suction Period</i>			
Wangensteen and Paine ¹	1933	32	15.6
Wangensteen et al. ²	1938	157	17.9
Johnston ³	1940	63	19.1
McKittrick and Sarris	1940	136	20
Leigh Nelson and Swenson ⁴	1940	76	13.2
Lewis Shapiro and Vaughn	1940	262	21.7
Schlicke Borgen and Dixon ⁵	1940	133	21.8
Dennis and Brown ⁶	1942	48	13.3

Selected personal series

¹ Only 11 staff members were responsible for management of these patients in the subsequent report (1938) 14 staff members participated

² 157 patients had 190 obstructions case mortality 14.7% Decompression achieved by suction above in 43.6% Mortality in suction group (without operation) was 7.8%—the mortality by case was 6%

³ Johnston's series does not include strangulating obstructions

⁴ Authors included 12 cases of intestinal distension not essentially mechanical in origin Mortality in mechanical obstruction group was 15.6%

⁵ Mortality amongst 33 additional patients with strangulating obstruction was 24.2%

Mortality during second half of period since report of Wangenstein et al in 1938

suction period as suggested by the latter reports listed in Table XXV a definite lowering of the mortality has come about

A number of factors contribute still to continuance of a mortality which should become lower As a number of reports have indicated the two chief stumbling blocks to better accomplishment with the bowel obstruction problem are (1) strangulating obstructions and (2) great distension in patients coming to operation In the series of McKittrick and Sarris strangulating obstruction was responsible for 59 per cent of the mortality and the problem of distension presented at operation accounted for 30 per cent of the deaths

CHAPTER X

THE MORTALITY OF ACUTE INTESTINAL OBSTRUCTION

A THE MORTALITY OF BOWEL OBSTRUCTION

UNTIL a few years ago, the universal complaint was that the mortality of operation for intestinal obstruction had exhibited no improvement since the beginnings of abdominal surgery, when it was debated whether medical or surgical management had most to offer patients with obstruction. A number of statistical studies indicated that this complaint was a just one. A number of studies indicated, at the same time, that distinctly better results were obtained in the cases submitted to operation early. In 1899 Sir Frederick Treves said, "Those who are enamoured of statistics could, I have little doubt, how that it is less dangerous to leap from the Clifton Suspension Bridge than to suffer from acute intestinal obstruction and decline operation." The experience of the past ten years has demonstrated that a number of patients can be decompressed satisfactorily, without recourse to operation. Yet, in the pitfall of treating a patient with an indwelling duodenal tube, who should be submitted to early operation lies a real danger.

Recent studies have shown a fairly general decline in the mortality of bowel obstruction for the first time. Nevertheless, of the cases that do die protraction until it is too late is often an important factor in the lethal issue. The admonition of operating early urged so frequently by experienced abdominal surgeons a decade and more ago, needs reemphasis to day, for many kinds of bowel obstruction.

At the Massachusetts General Hospital in Boston, there has been a keen interest in the bowel obstruction problem for many years. McKittrick and Sarris (1940) have reviewed recently the mortality of acute mechanical obstruction of the small intestine in that hospital. Previous reports, covering periods from 1898 up until 1928, have been made from the same hospital by Scudder (1908), Richardson (1920) and McIver (1932). Whereas, there was evidence of some improvement between the report of Scudder and McIver, for the first time in the history of that hospital, a distinct betterment in the results of treatment has become manifest. The tabulated data covering the forty-year period from 1898 to 1938, are summarized in Fig. 74. The present hospital mortality of 20 per cent is only one third of the initial mortality reported by Scudder. It is to be noted, too, that the number of patients submitted to early operation has increased remarkably, even during the years that suction, as a mode of treatment has been gaining favor.

The accompanying table, representing essentially a tabulation from McIver's (1934) monograph on obstruction indicates that, with few exceptions, the general mortality was essentially that reported in previous decades from the Massachusetts General Hospital. With advent of the

In addition, there is the hazard of treating patients by conservative management (suction) too long. When these patients come to operation later the technical problem is far greater, occasionally, than it would have been, had operation been undertaken initially. This increased hazard concerns essentially two things: (1) distension, increased in amount, over that present initially, and (2) decreased breaking strength of the bowel. On the gentlest manipulation, the peritoneal coat tears and after days of obstruction, as was pointed out previously, adhesive bands may become fused with the gut wall such that cutting or freeing them or any manipulation directed at removing the obstruction may cause accidental opening of the bowel with spillage at the site of fusion of adhesive bands and bowel wall.

The possibility of failure to achieve satisfactory decompression with conservative means (suction) prompted McKittrick and Sarris (1940) to suggest that all patients coming to hospital with obstruction within 24 hours after onset of symptoms should be subjected to immediate operation.

As in other ailments patients in advanced years exhibit an increased mortality. McKittrick and Sarris found that the risk run by patients over 60 with acute intestinal obstruction was 64 per cent. for patients 70 or over the mortality was 75 per cent. In our own cases of obstruction Dennis and Brown (1942) observed no increase of mortality with increasing years. Obstructed patients, without abdominal scars from previous operations, run a greater risk apparently than patients operated upon previously—owing no doubt to the greater confusion hedging about the diagnostic problem.

There are a number of obstructions such as congenital atresia of the new born, volvulus, mesenteric thrombosis, and the ileus of peritonitis which carry rather formidable risks.

B SUGGESTIONS TO DECREASE MORTALITY

The following appear to be significant items responsible for the continuance of an unwarranted mortality in obstruction.

1. Late diagnosis
2. Delay in hospital occasioned by
 - a) failure to recognize the presence of obstruction
 - b) improper identification of the type of obstruction present
 - c) treating patients by suction too long before recourse to operation
3. Failure to prepare patients adequately for operation
 - a) inadequate water and electrolyte replacement
 - b) inadequate replacement of blood volume losses in strangulating obstructions
4. Improper choice of therapeutic procedure
 - a) employment of suction in presence of strict contraindication or too protracted use of suction in patients presenting relative indications for its use
 - b) poor choice of surgical procedure

INTSTINAL OBSTRUCTIONS

In the review, covering the first seven-year period during which suction was employed in this clinic, the mortality concerned essentially (1) strangulating obstructions, comprised of the following items, a) strangulated incisional hernias, largely amongst obese, old people in whom correction of the defect, in the absence of obstruction, would have commanded great risk. Of 12 such patients, 7 died, a mortality of 58.3 per cent for

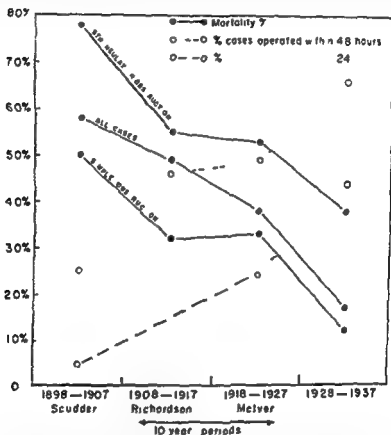


FIG 74.—The mortality from acute intestinal obstruction at the Massachusetts General Hospital over a 40 year period. The decline in mortality in the last decade is quite apparent (see also Table 25) (McKittrick and Harris New Eng Med J 222:611 1940)

the group, b) strangulated non viable intussusception. There were six deaths amongst 15 patients a mortality of 40 per cent. Despite the continued eleventh hour arrival of some such patients, with adequate blood loss replacement and employment of the closed (aseptic) oblique end to end anastomosis, the accomplishment in this group has been considerably better recently, and c) treating patients conservatively who proved at autopsy to have strangulating obstruction and should have been operated upon. In the group treated by suction alone there were 57 patients amongst which four deaths occurred. Two of these deaths occurred in patients with strangulated bowel.

In addition, there is the hazard of treating patients by conservative management (suction) too long. When these patients come to operation later, the technical problem is far greater, occasionally, than it would have been, had operation been undertaken initially. This increased hazard concerns essentially two things: (1) distension, increased in amount, over that present initially, and (2) decreased breaking strength of the bowel. On the gentlest manipulation the peritoneal coat tears and after days of obstruction, as was pointed out previously, adhesive bands may become fused with the gut wall, such that cutting or freeing them or any manipulation directed at removing the obstruction may cause accidental opening of the bowel with spillage at the site of fusion of adhesive bands and bowel wall.

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As in other ailments, patients in advanced years exhibit an increased mortality. McKittrick and Sarris found that the risk run by patients over 60 with acute intestinal obstruction was 64 per cent; for patients 70 or over the mortality was 75 per cent. In our own cases of obstruction Dennis and Brown (1942) observed no increase of mortality with increasing years. Obstructed patients, without abdominal scars, from previous operations, run a greater risk apparently than patients operated upon previously—owing no doubt to the greater confusion hedging about the diagnostic problem.

There are a number of obstructions such as congenital atresia of the new born, volvulus, mesenteric thrombosis and the ileus of peritonitis which carry rather formidable risks.

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4. Improper choice of therapeutic procedure
 - a) employment of suction in presence of strict contraindication or too protracted use of suction in patients presenting relative indications for its use
 - b) poor choice of surgical procedure

- 5 Faulty technical execution of surgical procedures, especially failure to perform an aseptic operation, in which no suggestion or evidence of spillage of intestinal content occurs
- II Uncontrollable Factors
 - a) obstructions, inherently difficult to deal with, such as congenital intestinal atresia or strangulated incisional hernias in obese patients with poor cardiac reserve
 - b) old age and its physical infirmities which contribute to operative mortality
 - c) great intestinal distension
 - d) strangulating obstructions

With reference to item "C," listed under Uncontrollable Factors, it is to be remembered that in every instance of intestinal obstruction at some stage, the distension was not great. The error, therefore, in a sense is one which could be avoided granted, 1) early diagnosis and 2) successful application of the correct therapeutic procedure. Similarly with item "D," granted early diagnosis and early and technically correct execution of the proper operative procedure, the problem of strangulating obstruction should not be so formidable. For, after all, with the single exception of mesenteric embolism or thrombosis, granted early operative release from the strangulating agent all forms of strangulating obstruction may be treated as instances of simple obstruction.

Concentration of the responsibility for management of patients with acute intestinal obstruction, in the hands of a few persons of each hospital staff, would augment considerably the general accomplishment in the problem. The important therapeutic problem in bowel obstruction is to achieve decompression before the ill effects of sustained increase in intraluminal pressure has impaired the viability of the bowel wall, causing increased capillary permeability. A small group in each hospital, who set themselves the task of wrestling with the problem, would soon make every hospital staff obstruction minded.

A better knowledge of the effects of obstruction, a more acute appreciation of the criteria which permit timely recognition of the presence and identification of the type of obstruction, and, finally, a more discerning understanding of the limitations and virtues of the available remedial agents, together with a keener interest in the technique of carrying out therapeutic precepts with precision—these are the important items in the bowel obstruction problem.

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PART IV

THE SPECIAL OBSTRUCTIONS

CHAPTER VI

CONGENITAL ATRESIA OF THE INTESTINE

A PATHOGENESIS

Frequency

This condition is relatively rare, occurring approximately once in every 20 000 infants. In 1877, Thoremin reported having found two cases over a period of eleven years among 116 451 children admitted to an institution for children in St. Petersburg. Ernst in 1916, reported the occurrence of two cases among 41,000 infants in Copenhagen. In 1926, Shelden stated that among 6 000 autopsies performed at the Hospital for Sick Children in London since 1900 there were 26 instances of congenital atresia and stenosis. In 1931, Webb and Wangensteen found mention of more than 500 cases of congenital atresia of the intestine in the literature. There appears to be an equal distribution of the cases between the two sexes. Denny and Sloan have recently described the occurrence of intestinal atresia in twins.

B THEORIES OF ORIGIN

A large number of causes have been advanced to explain the occurrence of intestinal atresia. The one that is given widest credence is that these areas of occlusion are due to persistence of epithelial buds in the intestine.

In describing the development of the esophagus of the elasmobranch Balfour referred to it as a solid organ and pointed out that only later did it acquire a lumen. Tandler has shown in human embryos between 30 and 60 days of age that the duodenum is solid and suggested that the atresia found in congenital occlusion of the intestine was due to failure of the bowel to acquire a lumen. Kreuter, who has also given the subject intense study in human embryos, concurs in this opinion.

Schridde examined the esophagus in a number of embryos and never observed a stage in which a lumen was not present. Forsner, who has been an ardent student of the matter, observed the presence of vacuoles in the esophagus and in the duodenum. In the esophagus he found that the continuity of the lumen was not impaired by the presence of these vacuoles, whereas in embryos of 16 mm. the epithelium throughout the extent of the duodenum was occupied by large vacuoles. He expressed the opinion that occurrence of atresia is due not to arrested development but to overdevelopment of the Mesenchymal Zapfen or forerunners of the villi. In embryos from 20 to 30 mm. in size these grow into the bowel and extend into the lumen so far that a mesenchymal bridge or diaphragm is formed

Stenosis may at first result, to be transformed later into atresia. Johnson studied the development of the intestine in the chick and found these vacuoles present in 16 mm embryos in the duodenum and jejunum. The lumen of the lower jejunum and ileum was found to be pervious throughout its entire length.

Theremin has been a strong advocate of the theory of fetal peritonitis as the etiological factor in the causation of intestinal atresia. Bland Sutton stressed the occurrence of developmental abnormalities in the intestine at the sites of "embryologic events," pointing out the frequency of alterations at the duodenum, the duodeno-jejunal juncture, the ileum in the vicinity of Meckel's diverticulum and at the ileocecal region. Fetal volvulus of the bowel has also been suggested (Kuliga), as has failure of development of the mesenteric vessels to a given area of the intestine (Wyss, Jaboulay). Among other causes that have been put forward, may be enumerated kinking of the bowel, especially at the duodeno-jejunal juncture, fetal intussusception, strangulation through a mesenteric orifice, inflammation or ulceration of the intestinal mucosa, and hypertrophy of the valvulae conniventes, and pressure at the head of the pancreas (Spriggs). The frequent occurrence of prematurity as evidenced by body length or weight has been noted by Pehu and Auberge.

Perhaps no one of these factors will adequately account for all cases of intestinal atresia but failure of a portion of the intestinal tract to acquire a normal lumen during its developmental period would appear to be the most plausible. In 1 out of every 10 instances, some other significant embryologic defect is also present (Spriggs). Of these, imperforate anus is the most frequent, in the 24 cases of intestinal atresia recorded by Spriggs, this deformity was present 4 times. Absence of some portion of the intestinal canal, congenital cystic kidneys, malformation of the extremities, and congenital heart disease are some of the developmental anomalies that occasionally accompany intestinal atresia.

C. PATHOLOGY

The most frequent site for the obstruction is in the lower ileum and jejunum, although it may be present at any point in the intestinal tract. In the 392 cases collected by Davis and Poynter, the following tabulation gives the location of the atresia:

TABLE XXVI—INCIDENCE OF SITES OF INTESTINAL ATRESIA

Duodenum above the papilla	59
Duodenum below the papilla	75
Jejunum	60
Ileum and cecum	101
Colon	11
Multiple areas	67

In the cases collected by Tandler, the occlusion was found to be present in the duodenum 33 times, in the jejunum and ileum 55 times, and in the colon 6 times. Vallois and his associates, in a collection of 224 cases, gave the following percentage of occurrence: duodenum, 33 per cent, jejunum,

and ileum in 53 per cent, and, in the large intestine, in 10 per cent of instances. Of the duodenal cases alone, Cordes, in a total of 57 cases, found the obstruction above the orifice of the common bile duct in 20, below in 13, and at the level of the duct in 2, the others were not classified. In a more recent report of 113 cases by Garvin, the site of obstruction was described as above the papilla in 34, opposite the termination of the common bile duct in 19, below in 25, and at the duodenojejunal flexure in 19, while 16 remained unclassified.

The obstruction is usually single, but in about 15 per cent there are multiple areas of atresia. In the multiple cases, Davis and Poynter found,



FIG 75—Multiple areas of constriction in atresia of the intestine of a newborn. The histology of the atretic area is well illustrated (Erb Amer J Path 2:137 1936)

in slightly more than 80 per cent, from 2 to 9 occlusions in the jejunum and upper ileum. In multiple constrictions, stenosis and atresia may co-exist. The point of obstruction may be narrow or moderately wide. Above the level of obstruction, the bowel is usually distended; in some instances so markedly that the pyloric ring is obliterated or rupture of the bowel may occur. Hypertrophy of the intestinal wall above the obstruction occurs, regularly, as shown in the accompanying photographs from case 1 in the series reported by Webb and Wangenstein. Below the obstruction the bowel is constricted and often ribbon-like, especially in low obstructions. The presence of bile in the contents of the lower bowel depends usually on the site of obstruction as related to the common bile duct. In some cases, however, bile-tinged meconium has been reported to have been present in the colon with complete obstruction of the duodenum below the papilla of Vater (Cordes). For this occurrence the presence of an anomalous bile duct or the development of the atresia after the fifth fetal month, at which time bile is normally present in the intestine, has been offered in explanation.

The degree of constriction may vary from stenosis to complete obstruc-

tion, an interruption—a gap in the bowel with or without the absence of the corresponding mesenteric segment, may exist. There may be a cord like structure connecting the segments of bowel, which may contain all the layers of the intestine, or its component parts may be unrecognizable. The photograph of a section through the connecting structure from such a case shows that it is made up altogether of fibrous tissue (Fig 7c). Sheldon reported a case in which microscopic section through the connecting band showed all the *normal intestinal layers* to be present, with the mucosa completely fused. Absence of a segment of bowel has been reported by numerous authors. Erb reported an instance of interruption of continuity of the jejunum, with isolation of a small segment, both ends of which were closed. Thomas reported the complete absence of the duodenum, the ileum, and the greater portion of the colon. The writer has observed a case in which there was not only interruption of continuity, but almost complete absence of mesentery.

Spriggs collected cases from several of the hospital museums in London and refers to the instance of an infant that had attained the age of 9 months with a septum like obstruction lying across the jejunum. He also refers to the instance of a boy who attained the age of 19 years with partial atresia of the intestine. Carling reported the case of a man aged 47 years, who had a stricture of the duodenum, apparently of congenital type, at the duodeno jejunal angle. Judd and White reported 2 instances of obstruction of congenital origin at the duodeno jejunal angle in patients 19 years of age. Cannon and Halpern described the instance of a child who had periodic attacks of obstruction who died at the age of 8 years with perforation of the stomach, a membranous septum exhibiting only a small iris like aperture at about the level of the papilla of Vater was responsible. Touroff and Susserman have reported recently an instance of prepyloric membranous obstruction in an infant for which division of the septum and pyloroplasty were performed successfully.

D CLINICAL FEATURES

After birth the infant ordinarily takes its first feedings well. In atresia of the lower ileum regurgitation of ingested milk may not occur for several hours. The bowels may move but there is usually no suggestion of bile pigment in the movement. Regurgitation occurs, as a rule, soon after the first nursing in duodenal atresia. The inception of vomiting is related usually to the location of the obstruction but there is, however, no absolute correlation. Helmholtz and Farr and Fries assert that they have observed cases in which no vomiting occurred up to the time of death. The meconium may or may not be tinged by the presence of bile pigment depending upon the location of the atresia. Bile is formed in the liver between the third and fourth months and finds its way into the intestine usually at the beginning of the fifth month. Intestinal atresia, if present, is ordinarily well developed at this time and the bile pigment will not find its way into the lower reaches of the intestine. In stenosis without complete atresia bile may find its way into the lower segments of the intestine. Cordes states that bile tinged meconium has been observed in complete atresia of the bowel below the duodenal papilla. Such an occurrence would appear to

be unlikely and would demand for a satisfactory explanation the presence of an anomalous insertion of the bile duct below the atresic area or development of the atresia in the bowel after the fifth fetal month following the appearance of bile in the intestine.

After a few days jaundice will occur if intestinal occlusion is below the ampullary termination of the common bile duct. This occurrence is of little value in the recognition of the disorder because of the frequency with which jaundice occurs in the new born. As a result of loss of fluid and lack of absorption, dehydration is frequently evidenced by anemic poor tissue turgor, depression of the fontanel, loss in weight, and fever.

The grade of distension present is determined by the duration of the obstruction and its location. When the obstruction is low, the abdominal distension may be considerable. Duodenal occlusions are accompanied only by distension of the stomach and the proximal duodenum. The absence of bacteria in the bowel distal to the obstruction and the exclusion of swallowed air from the oral source preclude the appearance of gas in the intestine beyond the site of occlusion (Fig. 76).

THE DIAGNOSIS

The expulsion of meconium untinged by the presence of bile pigment in a new born when associated with vomiting is presumptive evidence of the existence of intestinal atresia. In supra papillary occlusions the vomitus will fail to exhibit bile and the meconium is green. When the occlusion is at the papilla neither vomitus nor stool may contain bile. Farber (1933) has stressed the finding of cornified epithelium in the meconium as being significant of a bowel whose continuity is intact. Conversely, the absence of cornified epithelium (swallowed vernix caseosa) in the presence of obstruction suggests atresia of the bowel. That the fetus swallows amniotic fluid has been demonstrated nicely by Becker Windle and their associates (1940).

Roentgen examination affords reliable evidence. A film of the abdomen demonstrates the presence of intestinal distension. The location of the distended coils of bowel gives some information as to the level of the obstruction. It should be recalled here that whereas in the adult mere visualization of gas in the small intestine on the x-ray film is significant of intestinal twist, that gas is normally visualized in the small intestine of children up until past two years of age. The occurrence of bowel dis-



FIG. 76—Duodenal atresia. No air is visualized in the intestinal canal (Amer. J. Dis. Child. 41:262, 1931).

tion, an interruption—a gap in the bowel with or without the absence of the corresponding mesenteric segment, may exist. There may be a cord like structure connecting the segments of bowel, which may contain all the layers of the intestine, or its component parts may be unrecognizable. The photograph of a section through the connecting structure from such a case shows that it is made up altogether of fibrous tissue (Fig 75). Sheldon reported a case in which microscopic section through the connecting band showed all the normal intestinal layers to be present, with the mucosa completely fused. Absence of a segment of bowel has been reported by numerous authors. Erb reported an instance of interruption of continuity of the jejunum, with isolation of a small segment, both ends of which were closed. Thomas reported the complete absence of the duodenum, the ileum, and the greater portion of the colon. The writer has observed a case in which there was not only interruption of continuity, but almost complete absence of mesentery.

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D CLINICAL FEATURES

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of obstruction usually from birth but frequently months go by before the presence of a mechanical occlusion forcibly impresses itself upon the attendants, some such cases even reach maturity. As is pointed out in the section on strictures, a stenosis in the small bowel is often tolerated for long intervals, without symptoms. The presence of a diaphragm-like stenosis can occasionally be recognized at operation. Whenever obstruction occurs in the new born, intestinal atresia or one of its variants, viz, stenosis or a diaphragm in the bowel are always to be thought of. The determination of what type of obstruction is present must occasionally be left to operation (Cole).

G PROGNOSIS

The outlook is necessarily poor. Many pediatricists and surgeons have looked upon the condition as irremediable. Most untreated cases die within a week. A few infants with total occlusion have survived for a surprisingly long time. Theremin described an infant with complete atresia of the lower ileum that lived three weeks. Cases exhibiting intestinal stenosis as those of Carling, Judd and White, and Cannon and Halpern referred to above may grow into childhood or adulthood manifesting intermittently signs of interference with the continuity of the bowel.

H TREATMENT

In dealing with simple interruption of the continuity of the intestine in older children and adults the surgeon permits himself to be guided entirely in the choice of operative procedure by the condition of the patient. When the obstruction is late, an operation of necessity viz decompression of the bowel by enterotomy is done, whereas operations of election in which the continuity of the intestine is restored are reserved for the good risk patient. In conformity with this principle it would appear that the operation of least risk for the infant with intestinal atresia would be the performance of enterostomy.

It is a significant fact that all of the patients in whom enterostomy has been done have died. In 1902 Braun collected nineteen cases of congenital atresia of the intestine in which enterostomy had been done, with a lethal outcome in every instance. Tischendorf operating on an infant 11 days old found an obstruction 25 centimeters above the ileocecal valve. The child survived enterostomy for 15 days an occurrence which led Braun to suggest that this was the operation of choice for all cases of low atresia. Braun made his report, however, nine years before the first successful operation for intestinal atresia.

In 1911, Fockens of Rotterdam reported the first successful operative intervention for the relief of this condition. The case concerned an infant aged 7 days with atresia at the juncture of the middle and lower thirds of the small intestine. There was a defect about 4 centimeters in length in which the intestine was absent the proximal and distal ends of the bowel being closed. A side to side anastomosis was made with recovery of the patient. When Fockens made his report five months later, the child was well.

tension as visualized on the x-ray film and the audition of loud intestinal noises on auscultation of the abdomen are very suggestive of the presence of intestinal atresia. Gaseous distension of the stomach and first portion of the duodenum, without visible gas on the films throughout the remainder of the abdomen, suggests duodenal atresia. For, if the infant has not swallowed air, no gas will be visualized in the intestine on the x-ray film. In duodenal occlusion, splashing borborygmi are usually absent.

Whereas the administration of barium to detect the presence of acute intestinal obstruction is to be condemned because it often contributes to delay in diagnosis, in the recognition of intestinal atresia, the method has real worth. The oral administration of a thin barium mixture by mouth will quickly indicate whether the atresia is in the duodenum and the instillation of barium into the rectum will exclude a colonic occlusion. The information gained by these examinations does not consume much time and affords often reliable information as to the location of the obstruction and in some measure aids the surgeon in determining whether multiple atresic areas separated from one another are present. Any information that enables the surgeon to treat this most hazardous affliction more intelligently and with expedition at operation is well worth obtaining. Yet, if the diagnosis can be made without the administration of barium, it should be omitted. If barium is administered by mouth, the stomach should be washed out carefully, before an anesthetic is administered.

F DIFFERENTIAL DIAGNOSIS

The obstructive features of the malady are not easily mistaken. Anomalies of development of the mesentery, such as imperfect rotation and mesenteric fixation may give rise to volvulus, adhesive bands, a Meckel's diverticulum and imperforate anus may also cause intestinal obstruction in the new born. Atresia of the pelvic colon may be confused with imperforation of the rectum. The latter is easily excluded by inspection of the anal dimple or by passing a small bougie in case of doubt. The expulsion of feces obviously excludes imperforate anus. The absence of bile in the meconium immediately gives reliable aid in differentiating intestinal atresia from herniation of the bowel through an aperture in the mesentery as well as from congenital volvulus. In both these latter conditions, there is present almost uniformly moderate tenderness and rigidity of the abdominal wall incident to the presence of strangulated and infarcted bowel. A flaccid non-tender abdomen attends intestinal atresia, even though considerable distention be present.

The time relation serves to differentiate congenital hypertrophic pyloric stenosis from atresia of the duodenum. The symptoms of the latter are initiated soon after birth. Whereas the former rarely gives symptoms before the second or third week. Pyloric stenosis affects the male infant fifty times more frequently than the female. Intestinal atresia affects the male and female infant with equal frequency.

Incomplete atresia or so called congenital intestinal stenosis may be recognized by the identification of ingested food in the stool. This condition is rarer than complete atresia. Infants with stenosis have symptoms

the small intestine in the infant unless the external vent be made in the very terminal ileum, is doomed to failure from the start. Birgfeld reported the instance of an infant, aged 50 hours, on whom he performed a side to side anastomosis for atresia of the upper part of the ileum. An enterostomy was added also. Although the fistula closed in three weeks vomiting and distension recurred, necessitating a second operation at 4

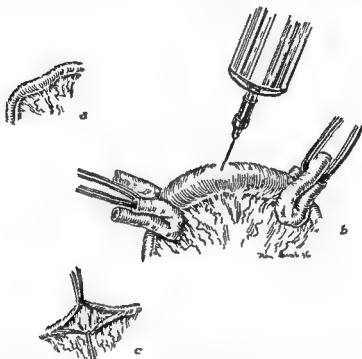


FIG 78—Method to increase the diameter of the lumen of the bowel to facilitate anastomosis in intestinal atresia. (a) The actual size of the bowel distal to the atresia obstruction. (b) Distension of its lumen with air. (c) Preservation of some of the increased diameter after incision. The anastomosis should be made with a single row of interrupted sutures of fine silk or with a single running Connell suture. (Amer J Dis Child 41:267 1931)

weeks of age following which the patient died. When the atresia is in the colon, a colostomy would appear to be the operation of choice.

Two factors contribute to the extreme difficulty and hazard in the surgical treatment of congenital intestinal atresia. A new born infant with intestinal obstruction is a poor operative risk; these patients tolerate the loss of vital fluids poorly, and, the small lumen of the bowel into which fluid from the proximal portions of the intestine has never made its entry, presents an exceedingly difficult technical problem. The performance of an intestinal anastomosis on such a bowel with preservation of an intestinal lumen appears to be an impossible task frequently (Fig 78).

The writer was privileged to operate upon two infants with intestinal atresia, both of whom died. These operations were done more than ten years ago. In both instances an entero anastomosis was made, in the first

In 1916, Ernst performed a successful duodenojejunosotomy for duodenal atresia in an infant, aged 11 days. Loitman referred to two other cases of high atresia in which gastrojejunostomy was successfully performed for congenital occlusion, both patients being well some time later. Richter recorded the instance of an infant, aged 4 days, with duodenojejunal atresia on whom he performed a successful posterior gastrojejunostomy. A volvulus of the ileum was reduced successfully also. In 1927 Weeks and Delprat reported a successful gastrojejunostomy, performed in 1916, for congenital occlusion of the third portion of the duodenum in an infant, aged 6 days. In the discussion of MacLennan's paper on acute intestinal obstruction in infancy and childhood, Cameron mentioned that a patient with congenital duodenal atresia had been operated upon by Steward, with complete recovery. Sweet and Robertson reported a successful issue after two operations on an infant for duodenal atresia.



FIG 77—Congenital duodenal stenosis relieved by duodeno-jejunosotomy

The infant was first operated upon on the ninth day of life a gastrojejunostomy being performed. Twelve days later, because of continued vomiting, a second operation was done, uniting the anterior aspect of the second portion of the duodenum to the jejunum distal to the initial anastomosis. Four months later, the child was in good health. Demmer recently reported a successful outcome in a case similar to that of Fockens. He resected the vestige of the terminal ileum and cecum and anastomosed the proximal ileum to the cecum. Smith did a low enterostomy on an infant with stenosis of the ileum that survived for 41 days. The Corkhills report another operative success after anastomosis of the ileum to the sigmoid flexure in an atresic ileum with concomitant imperfect rotation.

Miller has reviewed, recently, (1939) the literature of the results of surgical management of congenital intestinal atresia. Additional successes are being reported constantly. Donovan has had several successes. In their recent monograph, Ladd and Gross (1941) state that out of 52 patients with intestinal atresia, at the Children's Hospital in Boston there were 7 recoveries. There were 22 additional cases of congenital intestinal stenosis with 10 recoveries. (See also extrinsic stenosis Chapter XX.)

These and other operative triumphs probably now two dozen or more attest the fact that intestinal atresia is not irremediable. They indicate further that, an anastomotic procedure is the only operation that holds any promise of success. The establishment of a complete external fistula of

gut for this suture because it is more easily drawn through the thin bowel without damage to the wall. Silk sutures resist digestion also and afford firmer union. The open anastomosis is to be preferred to the closed in that no cuff need be cut away.

Duodeno-jejunostomy is a better operation than gastrojejunostomy for duodenal atresia, as Ladd points out. Further, gastrojejunostomy may be followed by a stomal ulcer, years after its performance.

It is essential to administer saline solution subcutaneously to infants who have not been able to utilize ingested fluids. They must also be kept adequately warm by the external application of heat. The performance of the operation with dispatch is important. Everything must be in readiness before the operation is begun. Infiltration of the abdominal wall with procaine hydrochloride will suffice usually, reinforcement with light ether anesthesia may be necessary. It is a good plan to attach two clamps to the skin on both sides of the wound. If there is any straining during the exploration, the skin may be pulled together across the wound and a threatened evisceration is thus easily obviated.

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infant, the anastomosis was a technical failure, in the second, a satisfactory anastomosis was made by inflating the collapsed bowel by the injection of air into its lumen before incising it (Fig 78) Even when incised, the bowel preserved an increased lumen permitting of an easy anastomosis The infant died unfortunately of hemorrhage An intact functioning anastomosis was demonstrated by necropsy (Fig 79) The administration of Vitamin K, to diminish the hazards of the hemorrhagic diathesis in an

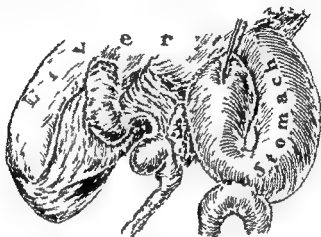


FIG 79—Gastro-jejunostomy for duodenal atresia. There is complete interruption of the continuity of the gastrointestinal canal at the points of juncture of the first and second portions of the duodenum. The common bile duct emptied into the summit of the second portion. Pancreatic tissue was directly interposed between the two closed ends. Drawing made of the anastomosis at postmortem (Amer J Dis Child 41 262 1931)

infants with atresia of the intestine would undoubtedly circumvent this difficulty. Vitamin K administration should be made in all such instances. A successful duodeno-jejunostomy has been done in a third infant with stenosis of the third portion of the duodenum (Fig 77). The operative technical problem, however, is not as great in infants where the bowel distal to the obstruction has been distended by intestinal secretions. Ladd has had several successes with this type of obstruction in the newborn.

In effecting the anastomosis between the distended proximal and distal collapsed segment, it is also a good plan to deflate the proximal distended bowel by milking out its content between the fingers or aspirating its content with a fine hypodermic needle after engaging the segment in a soft rubber covered intestinal clamp (Figs 47 and 48).

This procedure not only does away with soiling, but also permits the thinned out wall of the bowel to shrink. Only fine silk is to be employed in the suture. A single running suture after the Connell method will usually give a satisfactory anastomosis. A few additional interrupted sutures will give added security and adequate strength. Silk is to be preferred to cat-

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The rectum, he states, may be looked upon as having developed from two parts. At one stage of human development (embryo of 12 somites) the rectum ends by opening into the cloaca in its upper part in the neighborhood of the genital ducts. This is the older portion of the rectum. Imperforation usually concerns the new part that runs to the anal canal.

This anomaly of development is not infrequently associated with other embryologic defects, *Hypospadias*, *bicornuate uterus*, deformities of the external ear and external auditory canal, cardiac anomalies, abnormalities of the spine and of the lower extremities, especially clubfoot, are some of the most commonly observed defects found as associated with imperforate anus. Atresia of the intestinal canal at a higher level is only rarely observed as a complicating feature.

C. PATHOLOGY

Two types of imperforation are recognized viz, with or without abnormal fistulous communication of the terminal bowel. Stieda's classification on this basis is widely accepted. Stieda made a separate division of external fistulous termination of the bowel believing that these represented pathological abnormalities as differentiated from inhibition of normal development. Most authorities who accept his classification see no need for this differentiation.

TABLE XXVII—CLASSIFICATION OF IMPERFORATION

I Simple atresia			
(1)	atresia of the anal canal		
(2)	rectal atresia		
(3)	atresia of the anal canal and rectum		
II Atresia of the anal canal or rectum with fistulous communication			
(1)	vaginal		} female
(2)	external	vaginal commissure	
		perineal	} male
		scrotal	
		suburethral	
(3)	urethral		
(4)	vesical		

Ziemendorff collected from the literature 114 cases of imperforate anus between the years 1893 and 1909. These divided themselves as follows with reference to Stieda's table:

TABLE XXVIII—INCIDENCE OF VARIOUS TYPES OF IMPERFORATION

Type		Cases	Per Cent	
Type I	(1) anal atresia	28	24.6	51 cases 45.6 per cent
	(2) rectal atresia	16	14	
	(3) anal and rectal atresia	8	7	
Type II	(1) vaginal fistula	38	33.3	62 cases 54.4 per cent
	(2) urethral fistula	11	9.6	
	(3) vesical fistula	9	7.9	
	(4) external fistula	4	3.5	

Among 100 cases of imperforations collected by Curling (1860) in

CHAPTER XII

IMPERFORATE ANUS

A PATHOGENESIS

Frequency

ATRESIA of the anal canal or the lower portion of the rectum occurs about once in every 5000 births. Whereas a few smaller series of cases show the disease to be more frequent in males than females, larger compilations indicate that the incidence is about equally divided between the sexes. In 272,611 births at the Paris Maternity Hospital, the New York Lying in Hospital, and the Manhattan Maternity Hospital, as reported by Tuttle, the incidence of imperforate anus was one in 5,652 cases.

Heredity appears to play a role in some instances. Anders refers to the following illustrative instances. In 1885, Hadra reported a family in which six cases of imperforate anus were observed in several generations, in his text on surgery, König reported the instance of a boy whose two brothers and father were afflicted with the deformity, and Wirtza (1851), Anders states, observed the occurrence of the imperforate anus in three out of ten children in one family.

B EMBRYOLOGY

The primitive gut develops from the entoderm ventral to the notochord and forms a tube which becomes suspended in the embryonic coelomic cavity by being pinched off from the parent entoderm. The allantois develops from the ventral side of the caudal end of the primitive gut and becomes enclosed in the umbilical cord. The portion of the gut caudal to the allantois becomes dilated and forms the cloaca which is, at first, a blind sac separated from the outside by a thin membrane. The cloaca then splits into two portions—a dorsal from which the rectum develops, and a ventral from which develops the urogenital anus. When the future rectum reaches the perineal depression, it comes in contact with the closed ectodermal cloacal membrane. The dorsal migration of the rectum signals segregation of bladder and rectum which become separated by the urorectal septum. In the foetus, at the seventh week, the vestibular folds appear on either side of the perineal fissure, whose union with the urorectal septum separates the urinary and genital orifices from that of the bowel. Imperfect closure means a persistent cloacal anus in which the discharges of the bowel may be dumped into the bladder, urethra, or vagina. The anal plug in the cloacal membrane breaks down at the commencement of the eighth week forming the permanent anus (Keith). This process failing to occur, imperforate anus results.

Wood Jones points out that the malformation in imperforation in the majority of instances concerns the post allantoic gut, the portion of the hind gut caudal to the allantois that grows down and joins the anal plate.

present in 60 per cent of the specimens. In the male, he found that the most frequent malformation was termination of the rectum in the urethra; in the female, vaginal termination of the rectum occurred most frequently. The accompanying table from Keith's splendid article on malformation of the hind end of the body indicates the frequency of each type and the site of abnormality in the sexes.

The nature of the occlusion in anal atresia may be in the form of a thin diaphragm or the entire canal may be impervious. Stenosis without actual imperforation may go unrecognized till constipation and accumulation of fecal masses in the colon direct attention to their presence. Vernon David and Brenneman have each reported instances of this kind; the patients presenting themselves with megacolon. In rectal atresia the anal aperture may or may not be present. The rectum ends as a blind sac at a variable distance from the perineum. Fistulous communication of the rectum with the uterus has been reported (Anders). Due to the early segregation of urinary and genital passages in the female vesical and urethral terminations of the rectum are unknown in that sex. Communications with the bladder or prostatic urethra in the male are usually established by a narrow tract. In the instances in which a urethral communication was present Keith found that in 4 cases, the orifice was between 2 and 3 mm. in diameter; in 5 instances the orifice measured between 1 and 2 mm. in diameter. In 11 it was merely large enough to admit a bristle and therefore too small to allow the passage of feces. In all instances Keith found the orifice of the tract provided with a sphincter. In the bladder terminations, however, a cloacal type of communication is occasionally observed. Vaginal communication in the experience of the writer has usually been in the posterior commissure (Fig 81).



FIG 81.—Imperforate anus with termination of the rectum in the posterior commissure of the vagina.

In instances of imperforation with a fistulous communication obstruction to the outlet of feces does not at first obtain, later when the infant's stool attains a more solid form however the fistulous tract is inadequate to permit of normal defecations. In consequence large fecal masses may accumulate in the colon. Dilatation and enormous hypertrophy of the bowel wall as occurs in megacolon is not unusual. This occurrence is especially likely with vaginal external fistulous terminations of the rectum (Fig 82). Such fecal accumulations may lead to acute bowel obstructions and even perforation of the proximally distended cecum.

When the fistulous tract terminates in the urinary passages death from kidney infection usually supervenes before fecal obstruction occurs.

57 per cent of instances simple atresia was present, in the other 43 instances, some fistulous communication existed

Sir Arthur Keith found in examining the specimens of the London hospitals and museums that fistulous communications were more frequent than simple atresia (Fig 80) Such fistulous termination of the bowel was

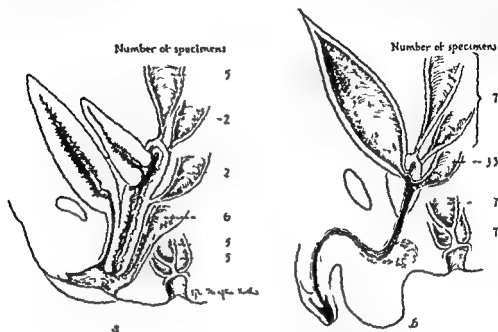


FIG 80.—Frequency of the various types of imperforate anus (a) In the female (b) In the male (After Keith Brit M J 2 1736 1903)

TABLE XXX.—SPECIMENS OF MALFORMATION OF THE RECTUM IN LONDON MUSEUMS (Keith 1903)

Groups		In Museum of Royal College Surgeons	In Museums of Metropolitan Medical Schools	Total
A Males				
1	Rectum opening in urethra	7	26	33
2	Rectum ending as a cord at or above base of prostate	0	7	7
	Rectum ending as cord at side of proctodaeum	1	0	1
B Females				
1	Rectum ending in vulva or vagina	1	5	6
2	Rectum ending as a cord at upper fornix of vagina	0	5	5
3	Rectum ending as cord at upper fornix of vagina	0	3	3
4	Rectum ending as cord on vagina below upper fornix	0	2	2
5	Rectum ending blindly or as cord at side of proctodaeum	3	7	10
		<u>12</u>	<u>61</u>	<u>73</u>

F DIAGNOSIS

No type of bowel obstruction is more easily recognized. Acquaintance with its occurrence serves to identify it. The recognition of the type of imperforation present is also usually easily made. The extent of the impervious bowel in simple atresia can not be made out, however, by the ordinary criteria of physical examination. A number of authors have

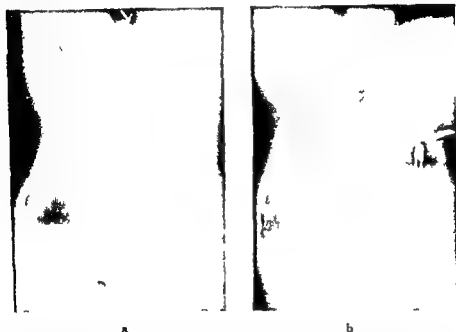


FIG 83—Method of demonstrating the extent of imperforation (a) In this instance only the anal plate remains imperforate (b) Atresia of the anal canal and rectum. Holding the infant up side down permits the gas in the bowel to mount to the highest point (Ann Surg 92 80 1930)

emphasized that abnormal narrowness of the inter ischial tuberosity measurement is indicative of an extra pelvic rectum. This information, however, may be equivocal and is not to be relied upon. The maneuver suggested by Wangensteen and Rice (1930) is of some help in this matter. When an X-ray film is made of the infant's abdomen and pelvis in the inverted posture (Fig 83) the height to which gas ascends in the pelvic colon and rectum serves to determine the extent of the imperforation. Isolated atresia of the colon as reported by Hamilton should be easily detected with the aid of this criterion (Fig 84). Should atresia of the small intestine or proximal colon coexist with imperforation of the hind gut, no gaseous shadow would be found in the pelvis when the X-ray film was taken in the inverted posture, inasmuch as the oral source of gas would be shut off proximally. The distension of coils of small intestine would establish the coincident presence of intestinal atresia. It is to be remembered, however, that gas is normally visualized on an X-ray film of the infant's abdomen up to about three years of age. In attempting to determine the

Bodenhammer records some very extraordinary cases of imperforation so fantastic that the most credulous would be rather skeptical of their occurrence. One of these, a girl of fourteen years, first reported by Baux (*Jour de Med de Paris* T 8, p 59) "had neither an anal, genital nor urinary opening. There was not the least appearance of these apertures, the skin being smoothly continued over the region naturally occupied by

them, as on other parts of the body. At the end of every third day, she experienced considerable pain around the umbilicus, and immediately after would eject fecal matter by vomiting. Her urine was entirely voided by the nipples every three or four hours. This girl was well formed in other respects and of a very agreeable person. She had a good appetite, slept well, and had general good health."



FIG 82.—Fecal impaction in the rectum and pelvic colon in imperforate anus with termination of the rectum in the vagina. The fecal mass is responsible for the opaque shadow. In the ascending colon and hepatic flexure the less dense collection of feces gives a speckled appearance.

communication exists with the bladder or urethra, discoloration of the urine with feces heralds its presence. In vesical termination of the rectum, the entire voided urine is tinged with meconium, and constant admixture of feces with the urine is the rule. When the communication is with the urethra, the first urine voided will be discolored, toward the end of micturition the urine will be quite clear. The vaginal termination of the rectum in the female infant is usually noted when defecation occurs as the infant's diaper is changed. The absence of the normal outlet and the spontaneous expulsion of meconium serve to identify it.

A child with imperforate anus takes its feedings in the normal manner for the first 24 hours before regurgitation commences. The abdomen only gradually distends. Absence of bowel movements or admixture of feces with the urine usually calls attention to the disorder before symptoms manifest the presence of the abnormality.

D CLINICAL FEATURES

Here inspection of the perineum in the new born serves to detect the presence of anal atresia. When the anal opening is normal recognition of the existence of imperforation is usually made when an attempt is made to insert a clinical thermometer into the rectum. In infants born outside of hospitals, the presence of the deformity is often later announced in failure of the infant to expel meconium. In those instances where an internal fistulous com-

rectum in the bladder or urethra unless relieved is followed by early death from pyelonephritis. A few exceptions are found reported in the literature. Page records the instance of a man of fifty-four in whom an unsuccessful attempt was made shortly after birth to establish the normal termination of the rectum. With the exception of a little fluid that drained away from the narrow sinus leading to the anal dimple that persisted after the early attempt at proctoplasty, he discharged all his feces through the urethra. At the age of ten, an incision had been made in the patient's urethra to remove lumps of feces that blocked its lumen. Page relates that the patient spent one and one-half hours daily milking feces through the urethra. At operation Page found the rectum to terminate by a fistulous tract in the urethra in front of the scrotum. He merely disconnected the communication and sutured the fistulous termination of the rectum in the perineum. The patient enjoyed such comfort after this procedure that he would not permit of the atresic rectum being brought down through the anal plate. Undoubtedly however a communication with the anterior urethra, as in Page's case, is better tolerated from the standpoint of kidney infection than the usual tract that ends in the prostatic urethra.

Kelsey reports the instance of a man of twenty-four years with anal atresia and vesical termination of the rectum. He had a perineal stricture from an attempt made in infancy to bring the bowel down. Some of his urine came out through the opening established in the perineum and some of the feces continued to be discharged from the bladder with the urine. Kelsey states that the man had gone as long as three months without an evacuation and had then filled two chamber utensils with solid matter.

G TREATMENT

Early establishment of external communication of the terminal bowel is indicated in complete atresia of the anal canal or rectum. When stenosis alone is present dilatation with bougies or the little finger well lubricated suffices. In external fistulous termination of the rectum in the male and vaginal communication in the female no indication for immediate operative intervention usually exists. In such cases the operation may well be deferred until a later period when transference of the lower bowel between the fibers of the external sphincter of the anal canal can be made with greater safety and more precision. If the termination is stenotic it should be dilated. When internal fistulous communication with the urinary passages exists the establishment of the normal termination of the bowel and severance of the abnormal communication are necessary to divert the fecal stream because of danger of urinary infection. That instances of this sort may reach mature age despite the persistence of such abnormal communication is demonstrated from time to time.

In those instances of simple atresia in which a diaphragm-like septum is present mere slit of the anal skin and dilatation with a hemostat is all that is necessary. Subsequent occasional dilatation with bougies may be required. In all other instances of anal or rectal atresia a perineal dissection should be made. In those instances where the lower portion of the rectum as well as the anal canal is atresic the operative approach is frequently difficult and uncertain. The presence or absence of the anal

extent of the imperforation by the x ray maneuver described herein (upside-down position), it is obvious that some time must elapse after birth, before enough swallowed air makes its way to the lower reaches of the intestinal canal. Paine and Nesser (1942) observed that, in the normal infant, gas can be observed in the upside down position on the roentgen film usually within 4 to 8 hours after birth. In the infant with imperforate anus, obviously because of the presence of larger amounts of meconium in the distal colon, the transit of gas to the most distal end of the intestinal canal may take a little longer.

In stenosis of the anal outlet without complete atresia, gas and meconium may escape when an attempt is made to pass a bougie into the rectum. Vaginal external fistulous and urinary tract terminations of the rectum are recognized by careful inspection of the perineum and observation of the urine stream during micturition. In the presence of a bristle like communication between prostatic urethra and rectum, admixture of feces with the urine may not be observed.

F. PROGNOSIS

In simple occlusion of the hind gut without fistulous communication, prolonged survival without the establishment of an external opening is

impossible. In the older literature one may find mention of instances in which such cases survived into childhood or adolescence, vomiting feces periodical-ly. In the absence of some fistulous orifice for gas or feces unless an outlet is afforded for their escape, death usually results within the first week of life and often from rupture of the distended colon. Survival into the third week of life is occasionally noted. Cripps refers to the instance of a well nourished girl, reported by Mercier, who had attained the age of thirteen years, vomiting fecal matter every fourth or fifth day. However, such phenomenal instances appear to be no longer extant. Patients with vaginal termination of the bowel usually prevent themselves when "diaper broke" for the relief of rectal stricture or in continence. Brenner refers to an instance reported by Morgagni in which a woman had borne several children and attained the mature age of 100 years without the existence of the defect having been brought to the attention of her husband and children. In the male fistulous termination of the



FIG. 64.—Skialogram of an infant with atresia of the colon. This condition is not to be confused with imperforation of the rectum. (Bowers and Cook, Arch. Surg. 34: 868, 1937.)

bowel. A two prong towel clip may be employed to lift the coccyx to give needed exposure. Matas states that no hesitancy need be felt in sacrificing the coccyx and lower sacral segments, which he cuts away with scissors. It is not necessary to do this very often, however. A midline incision causes less bleeding and avoids unnecessary injury to the fibres of the levator ani.

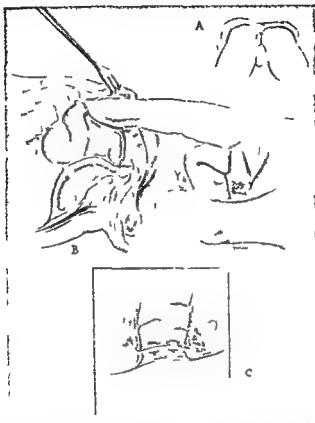


FIG. 85—Operative correction of imperforation of the anal canal and rectum. A The position of the infant on the operating table and the incision. B The usual site of occlusion when the rectum is imperforate. The coccyx is elevated with a small cat's paw retractor and the distended bowel is identified. C David's suggestion of inverting the skin to meet the rectal mucosa to insure a dry anal canal.

muscle. When the peritoneum is encountered and the bowel has still not been reached, Matas points out rightfully that the suggestion of Strohmer to open the peritoneum and pull the bowel down is to be preferred to colostomy. The writer, however, has not found it necessary to open the peritoneum often to tap the ballooned rectum. When interpretation of the x-ray films indicates that a pelvic colon is present, the bowel can be reached with greater safety to the infant from the perineum than by colostomy.

orifice gives no indication as to the condition of the rectum and the extent of the atresia

In all cases of anal atresia and in the majority of instances in which the rectum is atresic, the bowel can be reached from the perineum. As one examines the literature of operations for imperforate anus, he is impressed by the frequency with which colostomy is performed when the bowel can not be reached with ease from the perineum. Clogg recommends the immediate performance of colostomy without an attempt at perineal dissection. It is important to perform proctoplasty rather than colostomy whenever feasible because of the lesser risk of the perineal operation. Sir Arthur Keith says that in 95 per cent of instances the atresic bowel can be reached from the perineal route. Cripps, who had considerable experience in operating for imperforate anus states that he never had occasion to perform a primary colostomy. Ashhurst believes that only in unusual instances is it necessary to perform colostomy to decompress the obstructed bowel. In every instance in which an x ray film taken in the inverted posture demonstrates the presence of a gas filled pelvic colon, the bowel can probably be reached from the perineum. A part of the difficulty in the treatment of imperforate anus and rectum arises from the idea that if the gut does not reach the anal plate, it may terminate anywhere. As Wood Jones has pointed out however, imperforation involves almost invariably the post-allantoic gut and the segment of bowel concerned lies below Houston's upper fold of the rectum except in those rare instances where a concomitant atresia of the colon also is present. The evidence, furnished by x-ray films of the extent of the atresic area, serves to lend encouragement and assurance that persistence will reward the surgeon's efforts when a tedious and seemingly unsuccessful approach from beneath prompts him to open the abdomen and perform colostomy.

If colostomy is deemed necessary, it is a good plan to note the configuration of the colon on the x ray film from the distribution of the gaseous shadows. The sigmoid flexure is frequently more medial than is commonly suspected. The writer once saw the catheter in the left ureter at necropsy after supposed colostomy performed for imperforation. Ritchie has carried out successfully in 2 instances a combined abdomino-perineal approach. The pelvic colon is opened suprapubically and a curved hemostat is pushed through this colotomy opening into the distal segment. This maneuver serves to indicate where the rectum may be found and opened in the perineum. It would appear that this procedure presents a great increase in risk over proctoplasty, because of the hazard of infection.

Technique of Proctoplasty

The infant should be placed prone on the operating table, the buttocks being somewhat elevated by a small pillow placed beneath the lower abdomen (Fig 85). This position affords much better exposure than the perineal lithotomy position. Very light ether is the anesthetic of choice. Straining on the part of the infant facilitates finding the distended rectum. A midline incision from the coccyx through the posterior margin of the external sphincter affords usually immediate access to the distended proximal

The vaginal type of fistulous termination is so short that it may be dilated successfully to facilitate extrusion of impacted feces. Whenever a fecal impaction is present in the bowel, it should be evacuated before an attempt is made to establish a functional termination. The writer prefers to deviate the fecal stream by colostomy before attacking vaginal termination of the rectum through the perineum. Stone, however, states that he has been able to secure satisfactory closure of the recto vaginal fistula and proper anchorage of the rectum by primary perineal dissection. A longitudinal incision in the posterior wall of the vagina will usually permit of mobilization of the bowel. The rectum is then pulled through a small incision in the anal dimple and attached to the skin. The surgeon must be careful in mobilizing the rectum to preserve an adequate blood supply. The operation is carried out most easily usually in the lithotomy position. Germany advocated twisting the rectum somewhat to insure better continence. The posterior vaginal wall is then repaired. In external communications in the male, the approach is best made from behind the posterior margin of the anal plate the bowel being brought down in the operation for simple atresia. The fistulous tract extending anteriorly need only be severed, no necessity existing usually for dissecting it out.

Steudel reports the instance of a male infant with an external type of fistulous communication but which communicated with the urethra in front of the scrotum as in Page's case. Steudel states that two years after transference of the outlet of the bowel to the anal plate the patient could control a diarrheal stool.

It is to be emphasized that the treatment of imperforation does not end with the establishment of a perineal opening of the bowel. Unless the rectum is brought down to the anal margin, stricture formation is almost certain to occur. Walford reports the instance of a boy, aged seventeen, who died of perforation of the bowel consequent upon fecal impaction. Edington records the instance of an infant of two days with a scrotal fistulous termination of the rectum in which he cut across the scrotal tunnel and brought the rectum in communication with the anal opening. Edington subsequently learned from the mother that the child had died of obstruction at eight months.

When the rectum is not sutured to the anal margin before the infant leaves the hospital dilatation of the new opening should be begun. The mother should be instructed to do it daily with a bougie or the little finger. Harrison Cripps devised a little rubber nipple that was inserted daily into the rectum to obviate stenosis. My associate Dr. Richard L. Varco devised the glass dilator shown in Fig. 86 which has proved very satisfactory. In instances which demonstrate a tendency to contracture of



FIG. 86—Varco glass rectal dilator for treatment of stenosis after proctoplasty for imperforation of the anal canal and rectum. A glass blower can make them readily of varying sizes. The length of the dilator illustrated here is 4 cms and its width at the bulbous portion 2 cms and at the neck 1 cms. These should be available in graduated sizes.

In rectal atresia more often than in complete atresia of the anal canal, the surgeon will have to content himself with an operation of necessity, viz, insertion of a catheter into the bowel followed by dilatation of the tract after operation. Later when conditions permit, an attempt to establish a better functioning anorectal canal by bringing the bowel to the skin can be made.

Male infants with imperforate anus and urinary fistulous communication are not brought for surgical relief as early as a rule, as when simple atresia alone is present. Often they do not present themselves for deviation of the fecal current before the second or third week of life. Persistent or transient discoloration of the urine during micturition will usually distinguish whether a vesical or urethral communication is present. In case of doubt, a cystogram may differentiate. Urethral communications can invariably be reached from the perineum. The dissection is exactly the same as for complete anal atresia or imperforation of the rectum. The bowel should be sought close to the sacrum and coccyx. The operation of election is to pull the rectum down between the fibres of the external sphincter in the anal dimple and sever the short tract to the urethra. If occasion demands it, the surgeon should content himself with opening the bowel and attacking the urethral communication at a subsequent operation when the condition of the patient permits. Stettiner reports such an instance in which the prostatic urethra and rectum were separated one month after the initial operation. A sound was passed from the urethra into the rectum and the tract was easily identified. The opening in the rectum was closed and a small catheter was left in the urethra. It is to be remembered that the urethral communication is usually a small orifice. Bevan records an instance in which he did a primary colostomy believing that he had to do with a vesical communication, when a perineal dissection was done at five years the communication was found to be with the urethra and it had already closed. The writer once failed to note any admixture of feces with the urine, and even at operation, when the rectum was separated from the urethra and prostate, no communication was observed. The urine was discharged through the rectum but continence, for both urine and feces, was quite satisfactory. In the intervening years the continuity of the urethra has been reestablished. Young (1936) reports a similar case.

Vesical communications are probably better approached by the abdominal route. A cloacal type of termination of rectum and bladder, fortunately rare, presents an extremely difficult surgical problem. In such instances, the writer would prefer to deviate the fecal stream completely by preliminary colostomy. In the more frequent variety in which a small or narrow tract connects the bladder and rectum, the communication should be severed, the openings in bladder and bowel closed, and the latter adequately mobilized to permit of transference to its normal site of termination. A preliminary perineal dissection facilitates the bowel being brought down.

In instances, of vaginal termination of the rectum in the female and external fistulous termination in males, that come for the establishment of a functional anus, operation is well deferred until three years of age or later when the transference can be accomplished with greater precision.

The mortality incident to operation and pulmonary complications accounted largely for the large number of deaths in the first week. In the group in which proctoplasty was done, late deaths from intestinal obstruction due to stricture formation were not uncommon. Undoubtedly, considerably better results may be obtained today. The writer's experience with instances of imperforation of the anal canal and rectum has been very gratifying. Good remote results are also reported by David and Stone.

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the new outlet, the glass dilator is worn until the anal canal exhibits no further tendency to stenosis. When a satisfactory lumen has been obtained, the wearing of the dilator may be discontinued.

The external sphincter of the rectum is normally developed in all cases of atresia of the anal canal or rectum. This sphincter develops in connection with the perineum and not with the bowel. Hence if the proctodaeum is present, the surgeon may rely on obtaining an orifice provided with competent sphincters. The difficulty lies in properly anchoring the terminal bowel between the fibres of the sphincter. The writer has been much gratified with the continence which these patients have after completion of the operation. Chandler (1939) makes no effort to preserve the external sphincter and believes that satisfactory rectal continence may be obtained, nevertheless David (1937) takes pains, in the construction of the rectal outlet to turn in the skin edges to meet the rectal mucosa, in order to insure a dry anal canal.

II MORTALITY OF OPERATION

Bodenhammer collected 51 operative cases of imperforate anus from the world literature recorded up to 1879. Of this number he stated that 21 or 41 per cent were successful. This figure in part probably does not tell the truth of the matter because of the tendency to report isolated successes rather than failures. Ziemendorff collected 114 reported cases of imperforation in the 16 year period between 1893 and 1909 and found that the mortality of colostomy was 79.3 per cent. In the 78 cases in which proctoplasty was done, the mortality was 26.9 per cent. When the cases of atresia with vaginal communication were omitted, the mortality for proctoplasty was 40 per cent. The risk in each group was as follows:

TABLE XXX—MORTALITY OF IMPERFORATION

	Mortality
Atresia without fistula	28.6 per cent
Atresia with fistula	26.6 per cent
Atresia with fistula omitting the cases of vaginal communication	58.8 per cent

In the various types of fistulous termination, the mortality was as follows:

TABLE XXXI—MORTALITY OF IMPERFORATION ACCOMPANIED BY A FISTULOUS COMMUNICATION

Urethral	37.5 per cent
Vesical	83.3 per cent
Vaginal	9.1 per cent

I REMOTE RESULTS

In a Paris thesis of 1908, Hardouin has summarized the end results in 223 collected cases of imperforation. To say the least, they are disappointing as the following will attest:

TABLE XXXII—REMOTE RESULTS AFTER OPERATIVE CORRECTION OF IMPERFORATION

55.2 per cent survived one week
44.4 per cent survived one month
22.8 per cent were lost from observation during the first year
13.45 per cent survived for one year
5.82 per cent survived twenty years

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frequently multiple. There is an isolated type of tuberculosis known as the hyperplastic variety which occurs with predilection in the cecum and which may occasionally give rise to obstruction of a chronic nature. Syphilitic strictures of the small intestine have been reported. Following the ulceration of the bowel observed in bacillary dysentery and typhoid fever strictures causing intestinal obstruction have been reported (Braun and Wortman). The ulceration in typhoid is in the axis of the bowel and

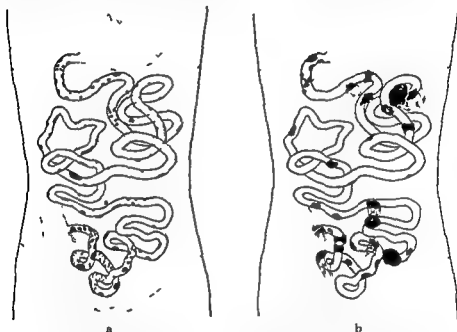


FIG 87—The distribution of benign and malignant tumors in the small intestine (a) Benign tumors (b) Malignant tumors the metastases are shown as radiating lines. The larger size of the malignant tumors is apparent (Ratford Arch Surg 25 122 1932)

stricture formation is a rarity. Intestinal obstruction, occasioned by narrowing of the greater part of the entire small intestine due to amyloid disease in a patient suffering from multiple myelomas was reported by Randall from this clinic in 1933.

In the sigmoid narrowing of the intestinal lumen due to diverticulitis may be observed as an occasional complication in patients past middle life. At the sites where the blood vessels penetrate the muscular layers of the colon hernial protrusion of the mucosa may occur. Infection in the sacs may give rise to an inflammatory process involving the whole bowel at that level causing obstruction of the lumen. The condition simulates malignancy so closely that it is best discussed with carcinoma of the sigmoid flexure.

Following blunt trauma to the abdominal wall in which a hematoma forms in the bowel traumatic stricture may ensue. It may also be men-

CHAPTER XIII

INTESTINAL OBSTRUCTION DUE TO TUMORS AND STRICTURES OF THE BOWEL WALL

PROVINE^{NT} among the lesions of the bowel wall itself that narrow the lumen and produce intestinal obstruction are the malignant growths. Of less universal interest to the surgeon are a group of conditions less frequent in occurrence but which occasionally bring the patient for relief of bowel obstruction. Benign tumors, intestinal strictures as the result of trauma, inflammation or previous infarction may be mentioned here. The venereal diseases—syphilis, gonorrhea, and lymphogranuloma venereum may give rise to rectal stricture. As the end result of a phlegmon in the small bowel, a cicatrizing stenosis may develop. Granulomatous inflammatory processes of uncertain origin also occasionally give rise to stricture formation. Ulcerative colitis not uncommonly is followed by the development of strictured areas in the colon.

A BENIGN TUMORS

These occur more frequently in the small intestine than in the colon. Lipoma, myoma, fibroma, adenoma, and angioma are the more usual offenders. Multiple adenomata or polyposis occur especially in the colon, the above mentioned tumors occur with predilection in the small bowel. Dewis reported 219 such benign tumors in the intestinal tract in 1906. They not infrequently cause intussusception. Of 42 lipomas of the bowel collected by Voehler, intestinal invagination was observed in 24. Of 986 tumors of the gastrointestinal tract from the Johns Hopkins Collection, Raiford found that 23.8 per cent of all the benign tumors in the group were to be found in the small intestine. All the tumors of the small bowel constituted only 8.9 per cent of the entire group and only 4.9 per cent of the malignant tumors of this series were found in the small intestine (Fig 87).

Enterocystomas of congenital origin usually found in the lower ileum and not infrequently associated with a persistent Meckel's diverticulum occasionally give rise to intestinal obstruction. Hannson has collected 48 such cases from the literature. Naeslund has collected in a recent inaugural dissertation 96 cases of gaseous cysts of the intestinal wall (pneumatosis cystoides intestinorum) in a few of which instances symptoms of intestinal obstruction compelled operation. Nitsch has also described obstruction as a complication of gaseous cysts.

B BENIGN STRICTURES

Of the inflammatory ulcers that give rise to strictures, tuberculous ulcer with its axis transverse to that of the bowel is the most frequent. It is usually the tuberculous ulcer that exhibits signs of healing that gives rise to stricture formation that eventuates in intestinal obstruction. These are

frequently multiple. There is an isolated type of tuberculosis known as the hyperplastic variety which occurs with predilection in the cecum and which may occasionally give rise to obstruction of a chronic nature. Syphilitic strictures of the small intestine have been reported. Following the ulceration of the bowel observed in bacillary dysentery and typhoid fever, strictures causing intestinal obstruction have been reported (Braun and Wortman). The ulceration in typhoid is in the axis of the bowel and

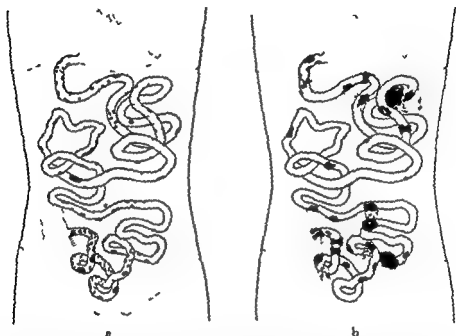


FIG 87—The distribution of benign and malignant tumors in the small intestine (a) Benign tumors (b) Malignant tumors the metastases are shown as radiating lines. The larger size of the malignant tumors is apparent (Ratford Arch Surg 25 192 1937)

stricture formation is a rarity. Intestinal obstruction occasioned by narrowing of the greater part of the entire small intestine due to amyloid disease in a patient suffering from multiple myelomas, was reported by Randall from this clinic in 1933.

In the sigmoid narrowing of the intestinal lumen due to diverticulitis may be observed as an occasional complication in patients past middle life. At the sites where the blood vessels penetrate the muscular layers of the colon hernial protrusion of the mucosa may occur. Infection in the sacs may give rise to an inflammatory process involving the whole bowel at that level causing obstruction of the lumen. The condition simulates malignancy so closely that it is best discussed with carcinoma of the sigmoid flexure.

Following blunt trauma to the abdominal wall in which a nematoma forms in the bowel, traumatic stricture may ensue. It may also be men-

tioned that the dissection of a large hematoma in hemophila has been known to give rise to stenosis. Stricture formation consequent upon blunt trauma to the abdomen usually occurs soon after the receipt of the trauma. After partial infarction of the bowel as in mesenteric thrombosis, such an event may occur. In the extraordinary picture of stricture formation over a considerable portion of the gut depicted by Porter and Welch, of an unusual case of intestinal obstruction of unknown origin, previous infarction would appear to be a likely explanation. At any rate, strictures similar to this are not infrequently observed in the dog following de-



FIG 88—Stricture formation after devascularization of the small intestine (a) Jejunum of dog excised 77 days after 15 inches had been devascularized by evering and ligating the mesentery near the bowel the omentum being then wrapped around it. When excised the length of the segment was 4 $\frac{1}{4}$ inches and the diameter of the lumen $\frac{1}{4}$ inch (b) Histological section magnified 10x shows the bowel wall to be receiving its source of blood from new vessels in the omentum. All the layers of the bowel wall appear to be somewhat thickened and the mucosa has been considerably altered.

vascularization of a segment of the intestine. Sometimes, following reduction of a strangulated hernia, a stricture may develop, an occurrence which has become well known since the paper of Garre. The inversion of ring-like areas of constriction by employment of interrupted sutures as recommended by Summers (Fig 114 p 351) will help to avoid such subsequent stricture formation. Occasionally strictures develop at the neck of an intussusception, some time after reduction. After intestinal resection in which the lumen of the bowel has been narrowed a stricture may form which may subsequently give rise to an arrest of the fecal stream especially when objects foreign to the intestine become impacted above it. The development of stricture in the bowel following irradiation treatment for malignancy of the female generative organs has been noted (Collins and Jones).

The surgery of these lesions is much as that outlined in carcinoma of the small intestine. The true nature of the obstruction usually remains obscure until laparotomy is done. In single benign tumors causing intus-

susception, enterotomy and excision should be done when circumstances permit. Occasionally it will be wiser to reduce the invagination and deal with the tumor later, but, employment of the closed anastomosis makes primary resection the operation of choice in such instances. In broad sessile or multiple tumors, intestinal resection is necessary.

The role of a generous omentum in protecting and vascularizing short lengths of devitalized gut is to be remembered. Bost reported the instances of three patients in which he sutured the omentum successfully over areas of 3 to 4 inches in length, following mesenteric detachment. Because of the major surgical problem present in each case, he chose this course of action rather than resection. The subsequent development of a stricture in some of these is to be anticipated unless the bowel wall was not wholly devascularized for, as Mall and Eisberg have shown, devascularization of two or three centimeters of the bowel wall usually brings about necrosis. In dogs, Scudder, Horsley and Coleman, Rothschild, and others have adequately demonstrated that considerable lengths of the bowel may be denuded and revascularized from the omentum. The writer observed several years ago in the experimental laboratory that dogs will revascularize regularly from the omentum as much as 5 inches (15 centimeters) of gut after severance of the mesentery. In one instance a dog survived after enveloping 15 inches (38 centimeters) of small bowel in the omentum. Stricture formation following such procedure, however, is to be anticipated (Fig 88).

C MALIGNANT TUMORS

Malignant tumors of the bowel causing intestinal obstruction are found most frequently in the large intestine. Nothnagel states that 25 per cent of cancers of the intestinal tract are to be found in the small intestine, 26 per cent are in the large intestine and 71 per cent in the colon.

In 41,838 autopsies performed in Vienna during the period from 1870-1893, Nothnagel found 3585 deaths from cancer of which 343 originated in the intestine. Their location is given in the following table.

TABLE XXXIII.—INCIDENCE OF CARCINOMA OF THE BOWEL

Ileum	10
Jejunum	0
Duodenum	7
Colon	164
Rectum	162

Carcinoma is incomparably more common as the cause of intestinal obstruction than is sarcoma. Rademacher collected 140 instances of sarcoma of the bowel in 1908, the greater portion of which distributed themselves in the small intestine. Stenosis of the lumen occurred in 14 per cent of these instances, but acute intestinal obstruction is relatively infrequent. In a recent monograph Staemmler states that 300 cases are to be found reported in the literature. Recent studies (Medinger 1939) suggest too that malignancy of the duodenum and ileum is observed more commonly than in the duodenum. The writer resected the terminal ileum for a lympho ar

coma causing intestinal obstruction in a woman who now exhibits no residual evidence of the disease after more than 16 years. Three additional cases which survived operation have been done recently in this clinic. One was a single lesion in the upper ileum. Perforation occurred while the patient was awaiting operation. The risk inherent in this tragic complication was not apparent in the record of convalescence. Another patient had multiple lesions through the mid two thirds of the jejuno ileum. It was believed to be an ulcerative jejuno-ileitis, but proved, on microscopic study, to be multiple lymphosarcoma (Fig 89). The third patient had an obstructing lesion in the ileocecal valve. Preoperative decompression was effected by an indwelling tube. The lesion involved the mid jejunum by extension, necessitating excision of a segment of jejunum. Primary oblique end to end anastomoses were made between the segments of jejunum as well as between ileum and transverse colon. Complemental enterostomy was not done.

The occurrence of bowel obstruction through the agency of metastatic tumor in the bowel is also to be remembered.

Carcinoma of the Small Intestine

Pathogenesis—Carcinoma of the small intestine is relatively infrequent, somewhat more than 400 cases having been reported in the literature to date. Many of these had already caused metastases at the time of their recognition. The greater number of them gave rise to symptoms of intestinal obstruction of more or less acute nature. To be differentiated from them is the carcinoid tumor of the small intestine of which Cooke, in 1931, collected 115 cases. It may also produce metastases (20 per cent). This latter tumor is more frequently found in the appendix. Intestinal obstruction through the agency of carcinoid tumors has been observed in 16 per cent of the reported instances. The lower ileum is most frequently concerned, but the duodenum, jejunum, and even Meckel's diverticulum have been involved. Oberndorfer suggested the name of "carcinoid" for this group of tumors in 1907. Carcinoid tumors are to be identified by the silver stain and are commonly called argentaffinomas. Carcinoma and carcinoid tumors of the small intestine are usually single, but may be multiple, the largest number occur in the fifth and sixth decades of life. There is no predominance in either sex. Nothnagel's series is unique in that no cases of carcinoma were observed in the jejunum. Raiford reports 88 cases of tumor of the small intestine from the Johns Hopkins material including 11,500 autopsies and 45,000 surgical specimens. Sixteen of these were carcinomas. Of these, 7 were in the duodenum, 4 in the jejunum, 3 in the ileum, and, in 2, the site had not been stated. There were 7 carcinoids of the small intestine in Raiford's group, of which 5 were in the ileum. Horsley (1941) states that in the interval of time elapsing since the publication of Raiford's paper in 1932, he was able to find reports of 384 additional cases of carcinoma and 100 carcinoid of the small intestine reported in the literature.

Pathology—Inte

on by this mechanism is usually of the
on does also occur. Dilatation of the

intestine with an accumulation of a considerable amount of fluid and gas in the proximal loops is usual. At operation, the bowel wall proximal to the obstruction over a distance of two to four feet or more is usually found thickened. Microscopic study shows the muscle to be considerably hypertrophied. In chronic obstructions the distension is likely to be largely fluid in character. In acute occlusions without antecedent obstruction, the content of the distended bowel is principally gaseous. By the time that the diagnosis of carcinoma is established metastases have occurred in about

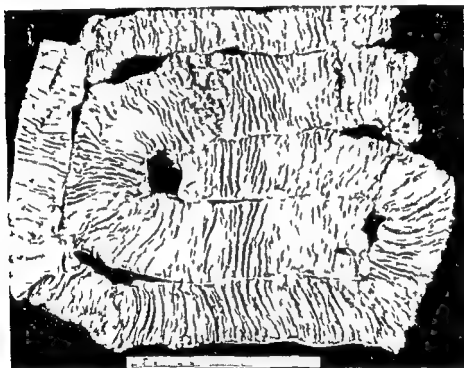


FIG. 89.—Multiple lymphosarcomas of the small intestine. The lesion at X had perforated on to the posterior abdominal wall causing obstruction. The multiple lesions in the bowel which proved to be lymphosarcoma on microscopic study necessitated excision of 180 cm. or 75 of the entire length of the small intestine.

25 per cent of instances. The mesenteric nodes, the peritoneum, the liver, and the lungs are the usual sites in the stated order of frequency. Stenosing, ulcerating, and polypoid forms may be recognized. Adenocarcinoma is the most common histological variety observed. Colloid carcinoma of the small intestine is rare.

Clinical Features—Of 57 cases of carcinoma of the small intestine collected by Soper in 1909, colicky pain was complained of 28 times, a palpable tumor was present in 22 instances. Progressive weight loss and vomiting were frequently present. Significant in arriving at the diagnosis, Soper (1929) stated in a more recent paper is the finding of occult blood in the stool when the colon and stomach are negative. Soper, Case and others

have made the pre-operative diagnosis of malignancy in the small intestine causing intestinal obstruction by demonstrating a filling defect with irregular contours in the small intestine as is more often seen in malignant disease in the stomach and in the colon. The diagnosis, however, is more readily made from the clinical findings. To be certain, a benign stricture of the gut cannot always be differentiated. Periodic attacks of acute obstruction with long free intervals between favors a benign stricture. Progressive weight loss and a shorter history speak for carcinoma of the small bowel. Enlargement of the abdomen may attend stricture formation in the small bowel as occurs commonly in the megacolon of Hirschsprung's disease (Fig 90).

In the experience of the writer, the correct diagnosis can usually be made on the basis of the presence of symptoms of intestinal stenosis due



FIG 90.—Enlargement of the abdomen in stricture of the small intestine. In an acute attack the hypertrophied coils of bowel could be seen and palpated. A Meckel's diverticulum causing intussusception had been amputated 6 months previously.

to narrowing of the lumen or stricture formation. The roentgenologist rarely identifies the presence of carcinoma of the small intestine by barium studies, for as can be understood the barium does not often accumulate proximal to the tumor in sufficient amount to cause a filling defect. In most instances that have come under the writer's attention the stasis ray will not detect delay of transit of barium through the small intestine. However, the balloon tipped Miller Abbott tube has been an agent of real value in identifying the presence of a lesion in the small intestine, if its presence is suspected. The usual history is that of periodic intestinal colic and occasional vomiting. If the patient comes for examination during such an attack, the intestine can usually be seen and felt with the palpating hand through the abdominal wall as a series of elevations and depressions (Fig 21, p 101) "wash board abdomen." A duodenal tube will ordinarily recover a feculent material from the stomach and the scout film of the abdomen will show dilatation of coils of the small intestine. Carcinoma of the ileocecal valve gives the picture of obstruction of the small intestine. If such an acute attack of obstruction subsides a stasis ray with barium may still fail to reveal the obstruction which was so obvious during the acute seizure and the scout film will show no gaseous distension of coils of small intestine. Similarly, the intestinal coils may now no longer be seen or felt. This unusual occurrence is to be accounted for in that the fluid content of the

terminal ileum may go through a stenotic orifice without great difficulty. If however the stenosis is almost complete, spontaneous reestablishment of intestinal motility and transport is not to be expected.

Treatment—In 1912, Hintz summarized the operative treatment of 44 cases of carcinoma of the small intestine, 16 of these showed definite evidence of stenosis. The prognosis in the group as a whole is poor. Hellstrom says that of 62 radically treated cases that have come to his attention, 16 per cent have been cured. Cases exhibiting evidence of obstruction come to operation at an earlier date.

It is an interesting and significant fact that in the four cases not exhibiting intestinal obstruction radically operated upon (Hintz), there was only one operative death. In the twelve instances in which resection

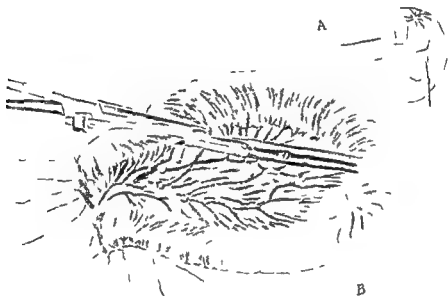


FIG 91—Primary resection of the small intestine for a malignant stricture causing obstruction. A The angle of resection. B Placement of the resection clamp upon the bowel. A heavy Ochsner clamp is applied just beyond the aseptic anastomosis clamp.

was done in the presence of intestinal obstruction, there were six operative deaths.

Preliminary successful decompression of such obstructions by an indwelling duodenal tube however puts a new complexion on the picture makes the task of the surgeon considerably easier and lowers the risk. When preliminary deflation can be accomplished by an indwelling duodenal or a Miller Abbott tube, a primary resection can be done. In event, the character of the distension is such that the duodenum can not be intubated the surgeon has a real problem to face, in relieving the distension by operation. He may choose one of the following (1) enterostomy

(2) exteriorization, with the establishment of an external fistula (3) entero anastomosis or (4) resection with primary anastomosis. More and more, the writer is inclined to extend the indications for employment of primary resection in such cases, employing, of course, the closed anastomosis. As has previously been pointed out (page 206) the surgeon who essays to do a primary resection in the presence of considerable distension must deal with the distension satisfactorily, before he can consider undertaking primary excision of the tumor. Possible maneuvers (aseptic decompressive enterotomy) by which the distension may be dealt with have been discussed already (page 209). The general criteria which determine the choice of operative procedure in such instances was discussed at length under the section of Operation in bowel obstruction (Chap. VII).

Carcinoma of the Large Intestine

Pathogenesis—It is in the sigmoid flexure that carcinoma is especially apt to eventuate in acute intestinal obstruction. This occurrence owes its



FIG 92—Carcinoma of the transverse colon (a) Roentgenfilm showing perforation into the descending colon (b) The excised specimen—the stomach was involved by extension demanding sacrifice of a good portion of the greater curvature. Primary resection with anastomosis between the transverse and pelvic colon was done. The lesion was excised en bloc including the abscess channel of communication between transverse and descending colon. The patient has remained well.

explanation no doubt in large measure to the fact that this part of the colon has the smallest diameter as well as to the fact that circumscribed annular growths frequently occur there. Obstruction in the left half of the colon is 8 times as frequent as obstruction in the right. In every 10 cases of colonic obstruction, 9 are due to carcinoma. About one third of the cases of carcinoma of the colon give rise to intestinal obstruction of an acute or chronic nature.

Korte stated that 39 per cent of the cases of carcinoma of the bowel which he collected presented themselves for treatment with clinical features of intestinal obstruction. Anschutz reports that 63 per cent of cases

of carcinoma of the pelvic colon give rise to intestinal obstruction, 52 per cent of the lesions at the splenic flexure 44 per cent at the hepatic flexure, and 25 per cent of those at the cecum obstruct. Included in this number are many cases with low grade obstruction.

Carcinoma is the most common tumor of the colon. Rankin, Barger and Buie state that up to 1929, 55 cases of carcinoma had been observed



FIG 93—Large primary carcinoma of the stomach involving transverse colon. A The crater of the gastric carcinoma. B Perforation on to the transverse colon causing partial colonic obstruction. Resection of the stomach with excision of the transverse colon and establishment of a colostomy. Subsequent closure of colostomy. As an alternative procedure primary resection of colon with oblique end-to-end anastomosis could have been made also. The patient has been well since operation 2 years ago. Carcinoma of the stomach invades the transverse colon and its mesentery necessitating partial colectomy not infrequently. Partial resection of the stomach because of extensions from a primary carcinoma of the colon is by no means frequent (see Fig. 92).

in the small intestine, 4597 in the colon and rectum and 4335 in the stomach. In this Mayo Clinic series carcinoma occurred most frequently in the pelvic colon and cecum and more commonly at the flexures. They call attention to the high incidence of obstruction in plenic growths owing to the acute angulation at the plenic flexure.

Of 458 cases of carcinoma of the colon observed at the Royal Infirmary at Manchester over a 10 year period 173 or 35.6 per cent, Burgess found exhibited evidence of acute intestinal obstruction. In 86.7 per cent of these cases the obstruction occurred in the left half of the colon.

The anatomical arrangement of the flexures is perhaps in part an explanation for the more frequent occurrence of obstruction at these sites than in other portions of the colon. The greater frequency of obstruction on the left side is due in no small part undoubtedly to the solid form assumed by the feces after the mid portion of the transverse colon has been passed whereas on the right side the feces are distinctly liquid. In the following table from Miller the incidence of carcinoma and obstruc-

tion in the various segments of the colon is apparent. Twenty per cent were admitted with acute obstruction and 40 per cent gave a history of chronic obstruction.

Pathology—Colonic obstructions are essentially simple in nature. The role of the ileocecal valve and sphincter in converting an occlusion of the colon into a strangulating obstruction with necrosis, gangrene and perforation, and usually of the cecum has been pointed out (p. 30). Hecht called attention to the importance of the ileocecal valve in bringing about perforation in the presence of colonic obstruction as long ago as 1880, but

TABLE XXX—INCIDENCE OF OBSTRUCTION IN CARCINOMA OF THE COLON
(Miller)

Location of Obstruction	Cases	Incidence of obstruction per cent	Acute obstruction	Chronic obstruction	Non obstruction
Cecum	50	33	2	24	24
Ascending colon	5	4	1	1	3
Hepatic flexure	12	9	2	6	4
Transverse colon	7	5	4	2	1
Splenic flexure	8	6	2	3	3
Descending colon	6	5	2	1	3
Sigmoid	40	31	12	16	12
Hepatic flexure combined with second growth in ascending colon	1				

the significance of its occurrence is not yet fully appreciated. Perforation is more likely to occur in acute obstruction than when the occlusion has developed slowly, permitting of thickening and hypertrophy of the bowel wall. The papers of Shimodaira and Sperling are of particular interest in this connection. In 1931 the hazard of the closed loop in colonic obstructions was first noted in this clinic. By 1934, the writer felt warranted in distinguishing, rather sharply, the findings of large and small bowel obstructions.

Volvulus may occur, especially when the obstruction is in the sigmoid flexure. Intussusception also occurs, but is unusual. It obtains with predilection in the presence of polypoid tumors and is most prone to occur in the sigmoid flexure and in the cecum. A chronic type of intussusception usually ensues. Carcinoma of the cecum, that causes acute intestinal obstruction, has often attained unusual proportions and metastases to the peritoneum or adherence to adjacent structures are not infrequent. Small constricting annular growths are frequent in the pelvic colon and may give rise to acute obstruction in the absence of antecedent symptoms. In the cecum, larger bulky growths are more frequent. Adenocarcinoma is most frequent, colloid carcinoma constitutes about 5 per cent of tumors of the large bowel. The cecum and rectum are the most frequent sites for its development.

Clinical Features—Acute intestinal obstruction occurring in patients of

middle and advanced years who have long complained of abdominal discomfort is often due to carcinoma of the colon. Almost invariably a history of constipation extending over some period of time is obtained, there frequently have been attacks of abdominal pain associated with temporary meteorism, during which time the expulsion of gas and feces, has been accomplished with extreme difficulty or not at all. The observation of blood or mucus in small quantities in the stool has, at times, been previously noticed, alternating periods of constipation and diarrhea may be complained of. Anschütz states that in his series, fourteen came with acute intestinal obstruction, as the first evidence of the disease. When such a patient presents him self for examination, the abdomen is frequently distended and occasionally the patterns of the colon may be seen in the form of a horseshoe shaped swelling around the periphery of the abdomen.

Vomiting is not infrequently absent altogether despite enormous distension. Occasionally vomiting may be present initially. The duodenal tube may reveal that gastric retention is absent. These significant findings owe their occurrence to the action of the ileocecal valve and sphincter and are of great value in helping to determine the exact nature of the obstruction present. A patient with occlusion of the colon may not appear particularly ill, yet it is one of the most vicious obstructions observed clinically.

Digital examination of the rectum frequently shows this cavity to be empty. Bimanual palpation aided with one hand over the abdomen occasionally renders a mass palpable which could not be felt by abdominal palpation or rectal examination alone. The abdomen though tympanitic, is moderately soft and not tender, when tenderness is present it is usually found over the cecum—a warning that the viability of the bowel is threatened by the enormous distension. The presence of weight loss, secondary anemia and a tumor mass in a patient of the cancer age lend confirmation to the probable presence of a neoplasm in the colon. A tumor is rarely palpable in the acute obstructions of the pelvic colon. Visible or palpable peristalsis can be made out occasionally when previous obstructive attacks have preceded. Intestinal colic is invariably present, the gas pains usually do not recur however at such short intervals as in obstruction of the small intestine. In consequence the examiner frequently finds it necessary to auscultate longer at the bed side to establish the presence of *intestinal colic*.

In the experience of the writer distension in obstruction due to carcinoma of the colon has been limited usually to the colon (Figs 12 and 23). When the film is made with the patient lying prone gas may occasionally be observed in the terminal loops of the ileum—probably regurgitated from the colon because of the compression brought about by having the patient lie on his abdomen. Gas may of course, be demonstrated in the ileum in patients with colonic obstruction—the usual cause being that one of the lips of the ileocecal valve is deficient (usually the lower lip), permitting ready regurgitation back into the ileum.

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(Miller)

Location of Obstruction	Cases	Incidence of obstruction per cent	Acute obstruction	Chronic obstruction	Non obstruction
Cecum	50	38	2	24	24
Ascending colon	5	4	1	1	3
Hepatic flexure	12	9	2	6	4
Transverse colon	7	5	4	2	1
Splenic flexure	8	6	2	3	3
Descending colon	6	5	2	1	3
Sigmoid	40	31	12	16	12
Hepatic flexure combined with second growth in ascending colon	1				

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Intestinal colic accompanied by great distension limited to the colon and little or no vomiting serve to identify this type of obstruction. One would naturally conclude that the barium enema would be of great help

in establishing the presence of the obstruction. When the roentgenologist finds a mechanical impediment to complete filling of the colon, on the administration of a barium enema, this examination contributes worth while information. Instances have come to the attention of the writer, however, in which barium went through the stenosis without great difficulty, and yet an obstruction so complete in nature was present that perforation of



FIG 64—Partial colectomy for malignancy of right colon. A Division of avascular ligament mobilizing colon. On completion of the operation this defect must be closed carefully taking care not to angulate the duodenum. B Completed oblique anastomosis between the end of the ileum and the transverse colon. The terminal 2.5 to 3 feet (50 to 75 cms) of the ileum is removed regularly with the cecum, ascending and right half of the transverse colon. Extension of a segment of the ileum is necessary with sacrifice of the mesentery to effect satisfactory lymph node removal and also because of sacrifice of the terminal ramifications of the ileocolic artery. Reversal of mesentery (Dennis) is shown here (see Fig 64).

the cecum was later found. One can only conclude therefore that in the presence of great distension the barium enema, even in practiced hands, is not to be depended upon for the identification of a tumor in the same measure, as when the lesion does not obstruct. The scout film of the abdomen correlated with the clinical findings is more reliable.

Differential Diagnosis—That intestinal obstruction exists in such patients is rarely demanding of proof. The determination of the exact type of obstruction can not always be made with certainty. Compression of the bowel by pelvic masses frequently cannot be differentiated except by the operative findings. Even operation may fail to differentiate a carcinoma

of the colon from diverticulitis. Their simultaneous occurrence, especially in the sigmoid flexure has been pointed out by W J Mayo and others. The presence of a palpable tumor, Judd and Pollock found to be more in favor of the presence of diverticulitis than of carcinoma. A barium enema will frequently detect diverticulas, but the aid of the microscope must occasionally be enlisted to determine whether malignancy may not be present concomitantly.

Obstruction of the small bowel can usually be readily distinguished by the occurrence of frequent and copious vomiting and by the distended loops of small intestine seen in the skiagram. One of the most difficult differentiations to make, and one which occasionally cannot be made without recourse to operation, is that of distinguishing a spastic obstruction of the colon from a mechanical block. The writer has previously described some of these difficulties (1931). The intervening years have not lessened the perplexity of this difficulty. If the barium enema were as reliable in detecting the presence of a block in the bowel when clinical obstruction is present as when it is not, this confusion would not obtain. The writer's practice has been to

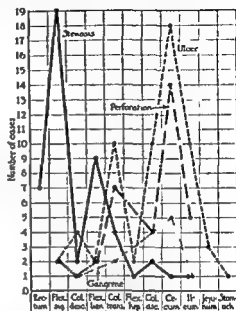


FIG 95.—The most frequent location of obstructions which give rise to intestinal perforations in simple bowel occlusion (Shimodaira Mitt. d. Grenzgeb. d. Med. u. Chir. 22:229 1911)

operate if an adequate differentiation cannot be made. Even at operation, granted that the distension is not too great to preclude careful palpation of the pelvic colon, a satisfactory distinction cannot always be made. If following the establishment of colostomy, a barium enema fails to disclose a block, it may be reasoned that the obstruction was spastic in character.

Treatment.—Nowhere is better illustrated the importance of merely relieving the distension at the first operation, than in surgery of malignancy of the large bowel. The mortality of operations for cancer of the large bowel in the presence of intestinal obstruction is more than doubled for the same type of operation done in the absence of obstruction. Korte has collected 58 cases of intestinal obstruction caused by malignancy of the colon that were radically operated upon—(cases operated upon by five surgeons—Mikulicz, Rotter, Eiselsberg, Korte and Berg). The mortality was 60 per cent. Exteriorization by the Bloch-Mikulicz method was made in 11 cases with a 63 per cent mortality. It is also too major an undertaking for patients ill with a neoplastic process and further handicapped by the presence of an acute intestinal obstruction. In 34 instances

in which the same 5 surgeons made a primary entero anastomosis, the mortality was 64 per cent, whereas the mortality of entero anastomosis in another 114 cases of tumor of the large intestine, in which no obstruction was present, was only 16.2 per cent (Körte)

The operation that enjoys widest usage in the relief of obstruction of the colon is cecostomy. The difficulty, however, is that it is almost impossible to do an aseptic operation on the distended cecum unless it is well exteriorized, unacceptable as such exteriorization may be, it also obviously would be exceedingly difficult to accomplish in the presence of great dis-



FIG 96—Perforations of the descending colon due to a carcinomatous stricture of the pelvic colon. Perforation occurred twelve days after cecostomy. The impaction of feces in the bowel and the acute angulation of the splenic flexure were probably responsible (Sperling Arch Surg 32:22 1936)

tension of the cecum. The writer has observed perforation of the descending colon after relief of colonic obstruction by cecostomy (Fig 96). In decompressing the distension of an obstructed colon, the writer has come to permit himself to be guided wholly by the x-ray film. In the majority of instances, the distension will be found to extend into the pelvic colon. The place of election for the establishment of decompression in such an instance will be the transverse colon. With an opaque object fastened to the umbilicus when the x-ray exposure is made (Fig 23) the incision can be placed directly over the distended colon. If it is presumed that the lesion is a carcinoma which will necessitate a subsequent operative attack, it is best to make a right transverse incision (Fig 50), if on the contrary, the operation is to be somewhat in the nature of an exploratory operation as well, a more direct approach to the pelvic colon will be had through a left transverse incision. A transverse incision is to be preferred in that the colon will present itself directly into the wound, at the same time, evisceration is much less likely to occur after this incision. Whereas the mortality of acute obstruction of the colon from malignancy was in the vicinity of 50 per cent at the University Hospital, when cecostomy was employed to decompress the distended colon the mortality, with employment of an aseptic method of decompression the colon, should ap-

proach zero. It is astounding how simple and effectual transverse colostomy performed after the method outlined on page 199 is. Cecostomy can never compete with it in ease of performance or in mortality. A second year surgical house officer can relieve an obstructed colon by an aseptic transverse colostomy with less risk to the patient than can an experienced surgeon who favors performance of cecostomy. As a complementary procedure to primary resections in the left colon appendicectomy or cecostomy is a simple and, occasionally, a desirable procedure.



FIG. 97.—Subtotal colectomy for polyps. There were 3 frank carcinomas in the bowel: one in the pelvic colon causing obstruction; one in the transverse colon; and another at the hepatic flexure. There were scattered polyps between. The rectum and cecum were free. The type of operation shown in Fig. 99 was done.

If the obstructive lesion is found in the hepatic flexure or nearer the site of termination of the ileum in the cecum, it is obvious that this obstructed segment must be tapped. If the vermiform appendix be present and patent the operation performed most readily will be found to be appendicectomy usually. Another manner of effecting the decompression with relative ease and safety is to perform enterotomy on the very terminal ileum, pushing the catheter through the ileocecal valve into the distended cecum. Cecostomy is to be reserved for the occasional case.

Carcinoma of the ampulla of the rectum gives rise to intestinal obstruction rarely. At the level of the peritoneal reflection, stenosis may occur though usually of the chronic variety. A left inguinal incision with the establishment of a complete diversion of the fecal current in such cases,



FIG. 98.—Primary subtotal colectomy for chronic ulcerative colitis. Operation completed in one stage as indicated in Fig. 99. The rectum and cecum were uninvolved. The patient gained 185 pounds in a few months and he remained well.

is indicated. The surgical treatment of diverticulitis causing intestinal obstruction is that of resection of the segment of the colon. Haberer's suggestion that a one-stage resection be done in instances of acute obstruction of the colon appears out of keeping with what experience has shown to be best in obstruction.

Technique of Dealing with the Neoplasm in the Bowel After Obstruction Has Been Relieved

As has been stated above, obstruction in the left colon is considerably more frequent than in the right. In consequence a number of patients with lesions in the pelvic colon and pelvic flexure, particularly have had to have a preliminary colostomy for the relief of obstruction. A number of patients with mild obstructive symptoms and with modest distension can be decompressed satisfactorily by an indwelling duodenal tube. At an early subsequent date, the operation of election may then be done without an antecedent decompressive operation. (For technical details see Chapter VIII.)

For a period of about four years it has been the practice in this clinic to perform resection with primary anastomosis for unobstructed lesions in both the right and the left colon. Within the past year, the standard practice has become to make an oblique end to end anastomosis, usually with omission of complementary enterostomy or colostomy. If an antecedent colostomy has been made for obstruction of a left-sided lesion, the colostomy is closed subsequently. When the colostomy is near the site of the tumor, however, the bowel employed in the colostomy has, on occasions,

been excised with the tumor—the operation being completed by the performance of a primary anastomosis.

For malignancies of the right half of the colon an oblique end to end anastomosis between the ileum and the transverse colon is made following

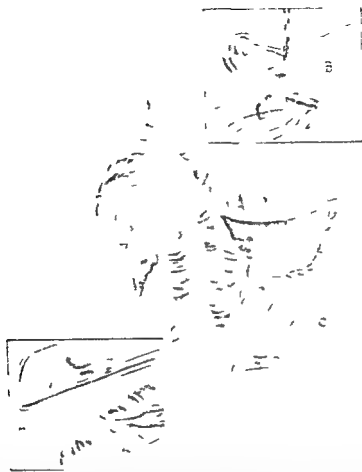
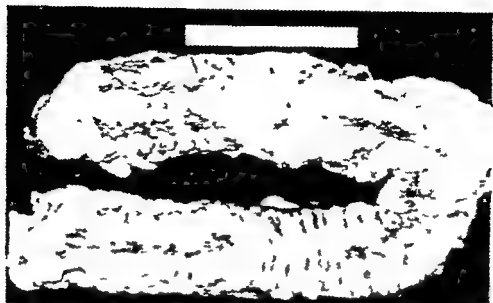


FIG 59—Subtotal colectomy for multiple lesions in the colon with end-to-side anastomosis between pelvic colon and side of cecum. This type of operation as a single stage procedure has been done for multiple carcinoma (pelvic colon and hepatic flexure) and for polyposis and chronic ulcerative colitis without involvement of the rectum or cecum. A Use of a Pezzer suture apparatus in the division of the ascending colon. B Inversion of the divided colon with interrupted Halsted mattress suture. C The completed oblique end-to-side anastomosis between side of cecum and end of pelvic colon. Closure of the mesenteric defect, as accomplished with surging case usually after subtotal colectomy.

excision of the cecum ascending and the first part of the transverse colon (Fig 94). In the sigmoid flexure mobilization with end-to-end anastomosis suffices usually (Fig 61). For lesions in the descending colon it has been necessary to mobilize both sigmoid and splenic flexures. In



1. The object is a large, ornate, and highly textured item, possibly a ceremonial mask or a large decorative item, featuring intricate patterns and a dark, possibly metallic, central area.

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stration in colon surgery. In small bowel resections, the mortality differences may not be so apparent. Yet, he who has schooled himself in the niceties of the closed anastomosis will come to prefer it to all others. In this clinic all anastomoses in the alimentary canal for more than a three year period, have been made by the closed method. The only occasion for dealing with an open bowel has been in the closure of colostomies. When surgeons come to appreciate generally the safety and the ease with which closed anastomoses may be made in the gastro-intestinal canal the procedure will come to enjoy more common usage.

For obstruction of the small intestine occasioned by neoplasms enterotomy, exteriorization and entero-anastomosis are alternative operative procedures. If the factor of distension has been dealt with satisfactorily by suction applied to an indwelling duodenal tube primary resection is probably the procedure of choice. The chief problem presented by such cases is how to deal with the distension. And, of course, were it not for this problem of distension, the surgery of intestinal obstruction would not be so difficult.

In the past decade the therapy of bowel obstruction has been advanced principally by employment, and extension of the use of suction applied to indwelling intestinal tubes. That method too has its shortcomings and for the years that lie immediately ahead, this writer believes that greater progress will come through improvements by the surgeon, directed at dealing with the problem of distension as presented at operation. Distension was the bugbear of surgeons before conservative decompression had its vogue, and it still is the stumbling block in the management of those cases in which suction has failed. McKittrick and Sarris (1940) have alluded to this circumstance recently also. Aptic decompressive enterotomy described under Caption Q in Chapter VII will lessen the hazards when operations must be undertaken in the presence of great distension of the small intestine.

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order to avoid tension at the anastomosis, the writer excises the splenic flexure and the descending colon, establishing intestinal continuity by primary oblique end to end anastomosis between the distal portion of the transverse colon and the pelvic colon (Fig. 99)

For a low-lying lesion in the pelvic colon, near or below the peritoneal reflexion, primary anastomosis may be difficult. In such a situation, it may be necessary to place the inner posterior sutures, before tying the outer interrupted row of Halsted mattress sutures. The anterior suture is not difficult to make ordinarily. The writer has transplanted successfully a loop of ileum with its blood supply intact, anastomosing it to the infra-peritoneal portion of the rectum, by oblique end to end union, in order to reestablish intestinal continuity after sacrifice of the pelvic colon. Such an anastomosis can be made only as stated above, by placing all the posterior sutures before any are tied.

A deterrent to reestablishment of intestinal continuity, apart from the technical difficulty involved in the procedure, is that excision of the entire pelvic colon necessitates sacrifice of the superior hemorrhoidal artery, the end vessel of the inferior mesenteric artery. In such instances, therefore, the residual rectum is dependent upon the middle and inferior hemorrhoidal arteries for its blood supply. When primary anastomosis is undertaken in such instances, care must be observed not to mobilize the infra-peritoneal portion of the rectum too much. Further, the color of the distal segment must be good before the anastomosis is undertaken. If the surgeon has any misgivings over the character of the blood supply to the lower segment, it is best to complete the operation as an anterior resection, by establishing colostomy and inverting the distal end or as a one stage abdomino perineal operation excising the rectum completely.

In the experience of the writer, the end results of excision of carcinoma of the colon are very good—probably superior to any other malignancy in the alimentary canal. There is far more justification for attempting aggressive, even palliative surgery for carcinoma of the colon than for gastric malignancies. The probabilities are that carcinoma of the colon is a less malignant neoplasm than carcinoma of the stomach. Primary resection presents a distinct advantage over the exteriorization operation in that it offers a better opportunity to excise completely the lymph node area involved. The writer does not hesitate to perform primary resection in the presence of hepatic metastases.

The experience of this clinic is that in the absence of a perforated lesion, primary closed anastomoses for colonic malignancy, can be done at a risk of about five per cent. It is the impression of the writer that in practiced hands, the risk of the primary closed anastomosis is definitely less than for the multiple stage Bloch-Paul-Mickulicz exteriorization. Mayo and Lovelace, in reviewing recently the experience of the Mayo Clinic in the surgical management of carcinoma of the colon came to the same conclusion.

In the opinion of the writer, the closed anastomosis presents such definite advantage over the open, from the standpoint of mortality that the open operation should be discarded. This thesis is particularly easy of demon-

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CHAPTER XIV

OBTURATION OBSTRUCTION

A INTSTINAL OBSTRUCTION DUE TO GALLSTONES

Pathogenesis

INTSTINAL obstruction, due to gallstones, owes its origin almost invariably to an abnormal communication between the biliary passages and intestine. Most frequently this internal biliary fistula is established between gall-bladder and duodenum, though such a communication between common bile duct and stomach or jejunum, ileum, or colon may occasionally obtain. There are on record reported instances in which an intestinal obstruction is said to have occurred in the absence of an abnormal communication. Moynihan refers to 2 instances of this sort, but it would appear very unlikely that gallstones large enough to cause a mechanical block could pass through the biliary tract into the intestine in the absence of such an irregular opening. However, it is to be admitted that gallstones have been known to cause intestinal obstruction when too small to block the lumen of the bowel. In such instances, a dynamic or spastic obstruction is brought about through the agency of the gallstone. The late Sir Frederick Treves found in the museum of Guy's Hospital a gallstone that weighed less than 4 grams (55 grains) that caused fatal intestinal obstruction. Such obstructions are undoubtedly spastic in nature and can be adequately dealt with by suction applied to an intlying duodenal tube. Two such cases have been treated conservatively, successfully by the writer in which the gallstone later appeared in the stool.

Gallstone obstruction, though infrequent, is decidedly not a rare occurrence. Wagner found a total of 334 cases on record in 1914. Gibson collected among 646 cases of intestinal obstruction, 40 of this variety. Barnard at the London Hospital over an 8 year period, during which time 360 cases were admitted to the wards, observed 8 cases of gallstone obstruction. In the papers of Fitz and Leichtenstern representing, like the series of Gibson, collected material, gallstone obstruction occurred in the ratio of 1 to 13 in the series of Fitz, and in Leichtenstern's series, 1 in every 28 cases was one of gallstone obstruction.

The usual site for the lodgement of the stone that causes obstruction is the lower ileum. Out of 239 cases of gallstone obstruction collected by Wolfer and Lieblum, 90 were present in the lower third of the ileum.

In the cases collected by Courvoisier, lodgement of the obstructing calculus was in the duodenum or jejunum in 21.4 per cent of the cases, in the ileum, in 65.4 per cent, in the ileocecal valve, in 10 per cent, and in the sigmoid flexure, in 2.4 per cent.

Stones large enough to occlude the lumen of the intestine are ordinarily about the size of a walnut. Round stones are much more likely to cause

obstruction than ones of equal weight with a greater length. Rough or faceted stones are apparently more likely to cause obstruction than those that are perfectly smooth. Enlargement of gall tones during their passage through the intestine may also occur. This is especially likely to happen if the stone remains in any portion of the intestine for any length of time, and particularly if medicaments, such as bismuth subnitrate, calcium or magnesium carbonate, are being taken orally. Grey-Turner has recently reported successful extraction of 2 gallstones from the transverse colon of an 81 year old man who had been obstructed from time to time over a period of many months. The larger stone was 7 inches (17.8 centimeters) in circumference and weighed 5 ounces (150 grams).

Holz tabulated 5 instances in which gall tone obstruction occurred in the same individual more than once. In 3 of these cases, the second gallstone was removed during the immediate convalescence such that it was likely that there were 2 stones in the intestine at the time of the operation, the existence of the second stone not being noted at the initial operation.

In consonance with the more frequent occurrence of gallstones in women, gallstone obstruction of the bowel occurs 3 times more frequently in women than in men. People of middle life and advanced years are most often attacked. Wortmann reports the instance of gallstone obstruction in a woman of 25 and states that this is the youngest age at which this type of bowel obstruction has been observed.

Pathology

Gallstone obstruction is usually of the simple variety in which a mechanical block alone is present. Occasionally such an obstruction partakes of the nature of volvulus, due to the fact that when fluid and gas accumulate above the point of obstruction owing to the increased weight of the segment such a loop may undergo torsion. Henning was able to bring about volvulus or torsion in ligated loops of cadavers by the introduction of water proximal to the obstruction. Mayo Robson and Smith have noted this type of intestinal obstruction by a gallstone. The presence of perforating ulcers in the intestine above the point of obstruction incident to the extreme dilatation of the intestine has been noted also. Occasionally necrosis of the bowel wall at the site of the incarceration occurs. Gallstones have become lodged in Meckel's diverticulum (Hanke).

Clinical Features

The history of previous gallbladder disease may occasionally be obtained, cholangitis may or may not have previously been present. Schuller noted the occurrence of fecal vomiting in 77 of 120 reported cases and a palpable tumor in 20 instances. The latter observation is significant of the fact that cases of this sort are very likely to go unrecognized for an unduly long time. By virtue of the nature of the obstruction, it is easily seen how this may obtain. The diameter of the upper intestine being larger than of the lower, the presence of such a body foreign to the intestine may initiate cramps during its transit through the upper intestine, it may

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become temporarily lodged at a given point, giving rise to mild obstructive symptoms, only to be swept on later by vigorous peristalsis and then, finally to the lower ileum, where the lumen of the intestine is smallest. This occurrence is an item of importance in the diagnosis. A stone may be present in the intestinal canal for some time before becoming firmly wedged and impinged in position. The persistence of Murphy buttons in the intestine for a long time with the late development of intestinal obstruction is well known.

Diagnosis

Though a correct preoperative diagnosis is rarely made if the condition is borne in mind it should be recognized in the majority of instances. As



FIG 100—Gall tone obstruction. The patient Mrs. A. T., aged 70. Univ. Hosp. No. 618442 had a story of abdominal pain of short duration with abdominal tenderness. The pain relented and recurred. A barium study of the intestinal canal caught the stone nicely. (6) A communication with the biliary tract is shown at 5. Enterotomy as shown in Fig. 102 was done.

was pointed out above an obstruction which relents and recurs should suggest an obturative type of obstruction. An antecedent story of biliary colic with cholangitis should suggest the possibility of gall tone obstruction. Occasionally, the diagnosis is made first, on inspection of an x-ray film. When gallstone obstruction is suspected to be present, films should be taken in several directions. Occasionally, a large biliary calculus in the intestine may be missed on a posteroanterior film, but may be recognized in an oblique film. The presence of air in the biliary passages suggests that the presence of an internal biliary fistula, through which the gallstone may have found its way into the intestine (Rigler and Borman 1937). When roentgen films have been made of the gall bladder previously, demonstrating the presence of a large calculus, the area should be re-examined, in the presence of *intestinal colic* to determine whether the shadow is still there. This occurrence has proved

helpful in a patient in this clinic, an occurrence which McWhorter reported as long ago as 1929.

In the experience of the writer obstruction occasioned by a gallstone, is attended usually by abdominal tenderness owing probably to progressive pressure necrosis at the site of incarceration of the stone. Whereas, obturation of the bowel is essentially a simple type of obstruction it exhibits early the effects of a strangulating obstruction, at the site of arrest of the biliary calculus in the intestine.

In the cases that have been observed in this clinic, during the last few

years, the diagnosis has either been made, or the presence of a gallstone suspected by one of the observers. In earlier years, the condition was diagnosed rarely. There is a definite story of *intestinal colic*, accompanied by vomiting. The pain relents for several hours, then recurs again with vomiting. This occurrence may be repeated several times, suggesting lodgement and forward progression of the obturative mechanism, corresponding in time to presence or absence of obstructive symptoms. The disorder is notably difficult to identify. However, consideration of its occurrence as a possibility helps immeasurably.

Neligan (1915) reported an instance of bowel obstruction in which gall tones were vomited into a pan with such force that the sound suggested that a volley of buck shot had been fired into a metal utensil. On counting them Neligan found there were about 30. Later Neligan says the patient passed a large stone while on the bed pan which produced so much noise that 'he and everyone else were frightened. The family summoned Neligan but they could not repress their curiosity and before he got there the stone had been broken with a hammer. Neligan naively remarks 'Surely Nature has never made a more determined or successful effort to get rid of gall stones'.



FIG 101.—Air and barium in the bile ducts. Evidence is good that there is an abnormal fistulous communication between the biliary tract and the intestine—the usual antecedent of gall stone obstruction.

Differential Diagnosis

Adhesive obstructions of the small intestine and an enteric intussusception have to be differentiated. Often this distinction can only be made

at operation. The vomiting, the pain and the distension as revealed in the x-ray film help to distinguish gall stone obturation from enterocolitis. The temporary periods of remission in the symptoms which may occur during the progression of the stone until it becomes arrested finally, may confuse the observer. It is to be remembered that this occurrence is not infrequent in gallstone obstruction.

Treatment

Suction applied to an inlying duodenal tube will accomplish decompression in some instances and permit extrusion of the stone. Per

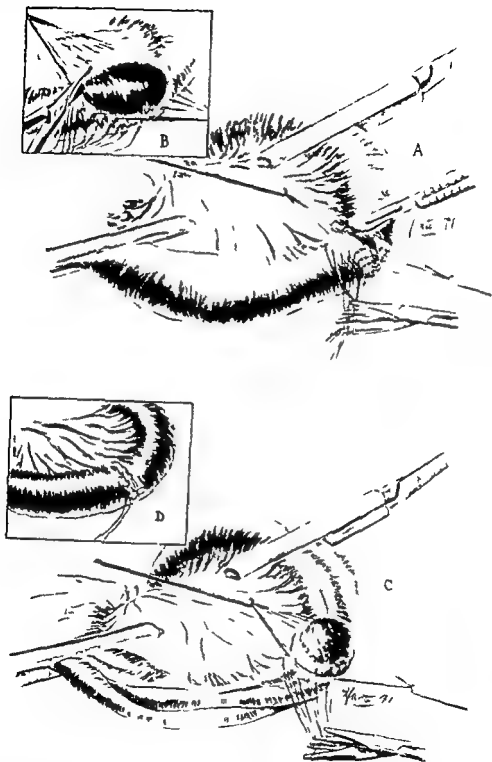


FIG 102—Technique of aseptic operation for removal of gall tone from intestine
 (A) Placement of Halsted mattress sutures. The stone has been dislodged proximally

sistence of intestinal distension, as revealed by x ray examination after a trial with suction, indicates the necessity for operation. Operation at the earliest possible moment is the treatment of choice. The segment of the intestine immediately proximal to the obstruction usually presents itself in the wound. In suitable cases, the gallstone in the intestine should be pushed upward and a transverse enterotomy incision made for its removal proximal to the point of incarceration where satisfactory healing is more likely to occur than if the incision is made directly over the site of incarceration (Fig 102). If possible, it is preferable to push the stone distally and remove it through a segment of bowel that has not been obstructed. This however, is rarely feasible. If distension is great an enterostomy should be made proximal to the point of incision.

Technique of Removal of Stone

The accompanying illustration indicates a satisfactory method of removing a gallstone without spillage—the important desideratum of a successful operation. Inter-

rupted sutures of fine silk placed after the mattress pattern of Halsted are placed and retracted with small hooks. The incision, transverse to the axis of the bowel is made midway between the near and far side of the sutures. When the stone is extruded the sutures are pulled up and a satisfactory closure is obtained. A second row of sutures may be placed over the first if it seems desirable to do so. When the stone is fixed at the site of its arrest and can not be displaced and the bowel wall overlying it is

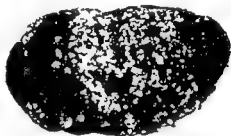


FIG 103—Photograph of gallstone causing obstruction. Removed by operation.

not viable it becomes necessary, obviously to place the sutures farther apart, than one would choose to do for removal of the calculus. As is indicated in the insert however this tissue may be trimmed away with scissors before the sutures are pulled up, to close the defect.

In a very obese woman who was also a diabetic the writer failed to excise the gangrenous area, at the site of incarceration of a very large faceted gallstone. The inversion left a bowel with a very small lumen

from its site of lodgement. A transverse incision is made between the sutures which are pulled aside with skin hooks. (B) Placement of sutures and wedge shaped excision of devitalized bowel where stone is impacted and has caused necrosis of the wall. (C) Removal of stone. The rubber covered clamps and previous stripping of bowel obviate spillage of intestinal content. (D) On removal of stone the sutures are pulled up and tied as indicated. A single row of well placed Halsted mattress sutures suffices usually to insure satisfactory closure of the defect. (See Figs 47A and B for technique of decompressing a distended loop of bowel before placement of sutures.)

It became immediately apparent that sacrifice of the large gangrenous patch would have been a wise course. Placement of an enterostomy tube (No 14F), 15 centimeters proximal to the inversion, sufficed to deal with the situation adequately. The stone was faceted, but because the patient was an exceptionally poor risk, no attempt was made to ascertain whether another stone was still in the gallbladder. The patient wore the enterostomy tube for two months following dismissal from the hospital. No symptoms of another stone having appeared and there being no demonstrable x-ray evidence of a residual stone in the gallbladder, the enterostomy tube was withdrawn. There was no leakage and the patient has remained well.

Whereas, a large gallstone, which has been drying in a bottle on the shelf for months, may be crumbled with relative ease, it is by no means easy to crush a biliary calculus in the gut. The writer tried it once, after proximal displacement of the stone. Several thicknesses of gauze were placed over the stone to protect the bowel wall. A large Payr type of gastric resection clamp was used. The blades of the instrument were sprung badly, but no dent was made in the stone.

Mortality

In the 40 cases reported by Gibson, 21, or 52.5 per cent, died. In the series reported by Wolfer and Lieblein, there were 145 cases operated upon with 82 deaths or a mortality of 56 per cent. Wagner found 82 deaths among 175 cases treated conservatively, a 47 per cent mortality, and 95 deaths among 159 cases treated by the operative method, with a mortality of 62 per cent. It would be extremely difficult however to be wholly certain of the real nature of some of the obstructions in the group not operated upon. Wortmann reports 6 recoveries and 1 death in 7 patients with gallstone obstruction over a 10 year period at the Friedrichshain Hospital in Berlin.

There have been no deaths in the last four cases seen in this clinic, employing the technique of enterotomy for removal of the gallstone depicted in Fig. 102. The persistently high mortality of gallstone obstruction has its explanation, in part, in late diagnosis, but failure to make an aseptic enterotomy is, probably, equally responsible.

No attempt should be made to close the abnormal communication between the biliary passages and the intestine at the time of operation. It is true that many internal biliary fistulas give rise to continued trouble, some symptoms and need subsequent operative repair.

B. INTESTINAL OBSTRUCTION DUE TO FOREIGN BODIES AND FOOD

Children accidentally swallow pebbles, coins, circular whistles, or the like that may give rise to intestinal obstruction. The majority of these however pass through the intestinal canal without particular event. Demented or hysterical persons not infrequently swallow objects of the most unusual character that lodge in the intestine and obstruct the bowel. Treves enumerates amongst others pins, needles, hooks, teeth, bones, nails, and screws. Indigestible materials of small size are likely to accumu-

late until they form huge masses that occlude the intestinal lumen. Fruit stones, husks of oats, vegetable fibers, grape skins, hair, wool, and yarn have all been known to be contributory to the formation of such masses. Storck, Rothschild and Ochsner have reviewed the literature of the subject recently (1939). Hair balls form most commonly in the stomach. It is astounding to what size they may attain without causing symptoms—the only complaint being that of tumor. A symptomless tumor conforming to the outline of the stomach, on manual palpation is likely to prove to be a hair ball. The writer once removed an enormous phytobezoar which filled the stomach of a young girl. In her convalescence she stated that the sense of satiety on eating had not been reached earlier when the hair ball was in it. The small bowel cannot accommodate itself as readily to the presence of such a body but fortunately lodgement of hair balls in the intestine is unusual. Obstruction through this agency does occur.

The late J. B. Murphy recorded an instance in which he recovered a large mass from the lower ileum in a case of intestinal obstruction which he identified as plum pudding, eaten by the patient years previously. Beer reports an instance in which Kirschner removed a Murphy button causing bowel obstruction, ten years after gastrojejunostomy. The central canal of the button had become plugged by the core of a pear. Klobner removed a Murphy button for a similar cause nine years after gastrojejunostomy. Kellogg reports removal of a Murphy button from the intestine fifteen and one half years after gastrojejunostomy in one individual and another after twenty years. The writer once encountered one accidentally in the bowel during laparotomy, which was believed to have passed, six years after gastrojejunostomy had been made. Obstruction was not present.

During the hunger period of the World War in eastern Germany and Russia several cases of intestinal obstruction were observed due to the accumulation of the husks of oats in the intestine. Brizke and Tigi have each reported a number of such instances, some of which caused perforation and peritonitis owing to the impaction of huge masses in the intestine. Tigi has placed 36 cases of intestinal obstruction of this sort on record and described the condition as 'oats ileus'. 4 were fatal. Many of the patients had eaten whole unground and uncooked oats. Millbourn recently reported 5 cases of bowel obstruction due to the ingestion of dried cooked fruit. Bran ingested in large amounts has been known to cause bowel obstruction (Davis). Havens (1939) reports fatal plugging of the intestine with colloidal aluminum hydroxide after 7 days of intra-gastric gavage—a treatment employed to control the pain of ulcer, occasionally.

C. INTESTINAL OBSTRUCTION DUE TO ENTEROLITHS

Enteroliths are seen very infrequently in man but occur commonly in the intestinal tract of horses. The occurrence of enteroliths in the human vermiform appendix is of course a matter of general knowledge. Their presence there is a sign of appendical stasis and obstruction. Enteroliths that cause intestinal obstruction may be divided into three classes. (1)

true enteroliths, (2) mixed enteroliths (phytobezoars), (3) intestinal concretions due to the ingestion of medicaments

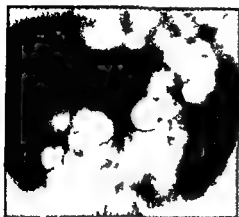


FIG 104—Retention of barium in diverticula of the small intestine. The patient was subject to attacks of pain and vomiting (See Fig 103)

cases Halstead and Bettmann and Blum have reported enteroliths imbedded in Meckel's diverticulum. Mixed stones form usually with a nucleus of the husks or peelings of fruits as their nucleus. Intestinal contents are then deposited about them in the alkaline medium of the lower intestinal tract. They are especially likely to be found in the cecum or terminal ileum.

Winterstein has reported the instance of a patient successfully operated upon sixteen years previously for carcinoma of the colon. At the site of anastomosis, a stricture developed, proximal to which approximately 1400 foreign bodies, principally fruit stones and particles of cellulose had accumulated. Incrustation with phosphorous and calcium salts had converted these masses into enteroliths which caused fatal intestinal obstruction.

Following the prolonged ingestion of calcium, magnesium, bismuth, and salol, intestinal stones may form. In painters and shellac workers the development of such stones has also been observed.

The clinical features of enteroliths that cause intestinal obstruc-

True intestinal stones usually present a small nucleus which may consist of intestinal epithelium, a small fecal mass, fruit stone, gall stone (Graham), or other foreign body about which alkaline mineral salts of phosphorus, calcium, magnesium, or ammonium may be deposited. The stones occur only in the presence of stasis and in an alkaline medium, therefore they are found with predilection in the large intestine and occasionally in the terminal ileum. Their occurrence in diverticula along the mesenteric border of the intestine has been repeatedly noted. Watson and Terry and Mugler have reported recent

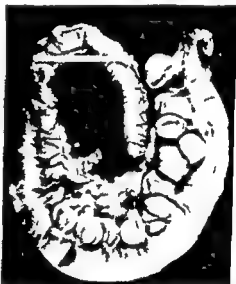


FIG 105—Excised segment of small intestine with sacculations. Though the continuity of the intestinal canal was interrupted the handicap to complete evacuation had caused the bowel wall to become considerably hypertrophied.

tion are not unlike those of intestinal obstruction due to gallstones or other foreign bodies in the intestinal tract. Many are opaque to the x rays. What was said concerning the surgery of gallstone obstruction obtains here also. Kelly reported resection of a segment of jejunum for recurrent obstruction, there were three enteroliths in the loop.

II. INTESTINAL OBSTRUCTION DUE TO WORMS

Intestinal obstruction caused by impaction of worms in the intestine has occasionally been observed. Kieselbach reports the instance of a 15 year old girl who was taken suddenly ill with abdominal pain and in whom a diagnosis of intestinal obstruction was made. The patient seemed ill out of proportion to the mechanical effects present. At operation, a loop of small intestine with a reddened, serosa and dilated bowel was found. Palpation of the bowel demonstrated the presence of worms. An incision was made and 62 ascarides were extracted.

Rost has isolated from worms that inhabit the intestinal tract, a substance that exhibits a marked stimulating effect on the tonus of the intestine of the cat. Herrick and Emery isolated a substance from an extract of *Ascaris* which increased the tone and rate of contraction of intestinal musculature. Instances of obstruction in which the accumulation of worms failed to mechanically block the lumen have been reported, in these instances, it has been felt that the liberation of a toxic substance from the worms occasioned spasm of the bowel with ensuing symptoms of intestinal obstruction.

The *Ascaris* is usually the offending agent and its ova may frequently be demonstrated in the stool. Most instances of obstruction due to worms have occurred in children. Instances have been reported in which the symptoms of obstruction occurred following the institution of vermifuge therapy. *Ascaris* infestation in tropical and subtropical climates appear to be frequent.

In a comprehensive paper upon the subject of bowel obstruction due to ascariasis Hoffman relates four types of obstruction with the following incidence:

TABLE XXXV—TYPES OF OBSTRUCTION AND INCIDENCE CAUSED BY ASCARIASIS

1. Obturation	65 cases
2. Intussusception	17 cases
3. Spastic	11 cases
4. Volvulus	6 cases

The disease apparently does not occur in nurslings but has its greatest incidence in childhood between the second and ninth years of life. It has been observed as late as the sixtieth year. In a group of 38 cases Schloeszmänn found multiple areas of worm obstruction in 12—usually not less than three. The lower ileum is the most common site for impaction of the worms.

Clinical Features

Obstruction may be acute or chronic. A tumor and visible peristalsis are frequently encountered in the latter variety. Tenderness and fever are

usually absent. The patient frequently appears ill out of proportion to the grade of obstruction, as indicated by the distension present. Apathy, somnolence, unconsciousness, and convulsions have been reported. The ova may frequently be demonstrated in the stool, vomiting is usually a

prominent feature in the acute cases—the vomiting of an *Ascaris* serves to establish the diagnosis (Levin and Porter). Laurell, Archer and Peterson and others have made the diagnosis of ascariasis following the oral administration of barium. If barium is given after a period of starvation, the *Ascaris* also ingests barium, if films are made at one, two, and four hours after the administration of barium, it can frequently be visualized in the intestinal canal of the *Ascaris* (Fig. 107).

Treatment

Frequently the nature of the true obstruction will be a surprise finding at operation—the worms being felt through the bowel wall. If the obstruction is in the terminal ileum, it is well to try to slide the packet of worms into the colon. Of 34 cases of *Ascaris* ileus treated medically, Hoffman reports death in 24 or 70.5 per cent. Of 23 subjected to operation and subsequent medical treatment, 4 died, a mortality of 17.5 per cent. In the removal of *Ascaris* by enterotomy, it is to be recalled that after incomplete removal, the *Ascaris* may crawl through the suture line and so give rise to peritonitis. This occurrence has

FIG. 106.—*Ascarides* causing acute intestinal obstruction. 801 worms were removed by enterotomy and 48 were later recovered *per os* and *per anum* (Levin and Porter, Brit. J. Surg. 11:432, 1923-24).

been noted after gastrojejunostomy (Pleu) and after gastric resection (Hofmeister). Genser has reported a case where, on withdrawal of the drain 23 days after appendectomy, an *Ascaris* came away with it. Recovery has been reported after resection of the segment concerned (McLean).

The accompanying table summarizes the operative procedures and the results in 23 surgically treated cases reported by Hoffman.

TABLE XXXVI—MORTALITY OF OPERATION FOR THE RELIEF OF OBSTRUCTION DUE TO ASCARIASIS

	Total	Died	Recovered
1 Laparotomy	1		1
2 Laparotomy with pushing a part of impacted packet of worms through bowel wall	3		3
3 Enterostomy without removal of worms	2	1	1
4 Enterostomy and removal of worms	16	3	13
5 Nature of procedure undetermined	1		1

Following convalescence after operation, treatment with vermifuge is important to establish cure. Santonin and oil of chenopodium are most effectual. Hoffman recommends the oral administration of 8 to 15 drops (depending on age) of santonin in two doses with a two hour interval in the morning. Two hours after the last dose, half an ounce of castor oil is given. If it is believed that adult forms of the *Ascaris* are still present, the same treatment should be repeated on the following day.

Because of the nature of the life cycle of the worm, it is apparent that many administrations may be necessary to rid the patient of the infestation. The life cycle of *Ascaris*, worked out on rats was first described by Stewart in 1916 and is briefly as follows. The ova from polluted soil are ingested and hatch in the small intestine of man. The larvae then migrate through the intestinal wall and enter the circulatory system and are carried to the capillaries of the lungs. In the pulmonary alveoli, they develop, ascend the bronchial tube and are swallowed. After being liberated from the lung the *Ascaris* attains maturity in the intestinal canal in six weeks.



FIG 107—Demonstration of *ascaris* by roentgen examination. The patient ingests barium after a period of starvation (overnight) and the *ascaris* also ingests the barium into his intestinal canal making visualization of the worm possible (Archer and Peterson J. A. M. A. 95:1819, 1930.)

E. INTESTINAL OBSTRUCTION DUE TO MECONIUM IN THE NEWBORN

Forrer described the occurrence of intestinal obstruction in the newborn due to thickened meconium in a Strassburg dissertation in 1895. Landsteiner, in 1905, again called attention to the possibility of this occurrence. Bullowa and Brennan described a case in 1919 thinking it the first case of the kind reported.

Exalto in 1925 described the instance of a child three days of age who came for operation because of vomiting and other signs of intestinal obstruction, no meconium having been passed. At operation the nature of the obstruction was not determined and operation was desisted in because of the poor condition of the infant. At postmortem, many loops of small intestine were found dilated, the large bowel was empty. In the terminal ileum many small whitish yellow plugs adherent to the mucous membrane and not easily loosened from it were found. When unrolled they appeared like long flat casts of bowel wall. These casts consisted largely of mucus epithelial cells and calcium carbonate. Adamson (1939)

and Hild (1939) report meconium obstruction in an infant of 36 hours and state that 22 cases have been reported in the literature

Fanconi has also described a similar instance of a large fecal mass of meconium obstructing the lower ileum. The child lived almost three days and the postmortem examination showed thick meconium in the terminal ileum. The author postulated a lack of normal bile flow into the intestine had contributed to the solidity of the intestinal content.

Mracek found in such a case inflammatory changes in the bowel wall, liver, and pancreas, and felt that these contributed to the thickened meconium.

Sara Meltzer recently reported an instance of meconium ileus in which a rent was found in the bowel, on postmortem examination, at the hepatic flexure. No meconium was present in the bowel beyond the splenic flexure, but the lumen was apparently normal. Kornblith and Otani relate a similar occurrence in which two perforations were found in the ascending colon. At autopsy, obliteration of the duct of Wirsung in the pancreas was also found. The authors suggested that the lack of pancreatic ferment in the bowel had been responsible for thickening and inspissation of the meconium. Instances of this sort have been described in the older literature. Zillner related 4 cases in 1884, in which perforation of the pelvic colon had occurred. He discussed the possibility of tension perforation of the bowel due to competency of the ileocecal valve as described by Heschl in 1880 and dismissed it, concluding that it was an accident incident to passage of the infant through the parturient canal. Paltauf, Sury, Fischer, and others have described similar occurrences.

This phenomenon is well known in obstruction of the colon in adults and occurs occasionally as well in imperforation of the anal canal or rectum in newborns. In the chapter on spastic ileus, obstruction through the agency of spasm in the pelvic colon is described, in Hirschsprung's disease, release of the spasm of the intestinal musculature by sympathectomy not infrequently does away with the fecal stasis. It is not unlikely that many instances of so called meconium ileus more properly belong in the category of spastic ileus.

Perforation of the ileum and of the jejunum in the newborn have also been reported, the etiology of which remains obscure (Generisch, Markowitz and Loar).

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CHAPTER XV

FECAL OBSTRUCTION OF THE BOWEL (HIRSCHSPRUNG'S DISEASE, MEGACOLON, CONGENITAL IDIOPATHIC DILATATION OF THE COLON)

A PATHOGENESIS

THE most frequent cause of fecal obstruction of the bowel is congenital enlargement of the colon and rectum. The first complete description of the disease was given by Hirschsprung in 1886 and since then the disease has been known by his name.

The typical variety of Hirschsprung's disease begins early in infancy with progressive difficulty in obtaining satisfactory bowel movements. The abdomen enlarges and the sigmoid loop of the large intestine can frequently be made out over the abdomen. The bowels may not move for days and in the series of cases reported from Mendoza in the Argentine by Corbin where the condition is said to be prevalent in adults, evacuations may not obtain for weeks at a time. Over a period of 22 years Corbin writes that 200 such cases of megarectosigmoid have come under his supervision. When the condition makes its first appearance in adult life, it is usually described as pseudo megacolon. Many theories have been advanced as to the cause of the disease among which may be mentioned mechanical neuropathic, inflammatory and congenital abnormalities. Barrington Ward has pointed out that abnormalities are frequent in the hind gut and believes that a number of these cases have their origin in such an explanation.

David has reported 3 cases of megacolon in infants in which a stricture of the rectum was present and reference has already been made to such cases reported under the heading of incomplete rectal atresia by Brenne-mann (p. 184). Rectal stricture apparently is a common cause of megacolon.

A number of years ago Perthes observed in a patient upon whom he had performed a colostomy for congenital enlargement of the colon and rectum that fluid administered by rectum came out of the colostomy with ease whereas when given from above it appeared to be retained and did not enter the rectum. Examination showed that the mucous membrane folds of the upper rectum caused a mechanical block. Following division of these folds marked improvement ensued. Lawen and Gant have also treated patients with congenital megacolon by division of Houston's folds with apparent success.

The motor nerve of the intestine is the vagus except for the sphincters of the bowel at the pylorus, ileocecal valve and O'Beirne's sphincter at the juncture of pelvic colon and rectum. The sympathetic influence it is felt regulates motor activity at all of these points. The fibres of the vagus however have only been traced as far as the right half of the colon. It has been suggested that failure of normal relaxation of the sphincter at the

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distension was so great as to lead to perforation and peritonitis. In some cases an associated tuberculous peritonitis brings about the presence of fluid in the peritoneal cavity. The essential pathologic changes in the bowel are hypertrophy and dilatation. The bowel may assume enormous proportions.

C CLINICAL FEATURES

A large protuberant abdomen and a history of difficulty in defecation usually establish the diagnosis without much difficulty. X-ray examination of the abdomen employing the scout film shows mottled shadows owing to fecal accumulations. Fecal masses can usually be felt through the abdominal walls. Emaciation is frequent. Despite the large accumulation of fecal material in the bowel, a history of vomiting is rarely obtained even in the presence of acute intestinal obstruction. The accompanying illustration indicates the degree of dilatation of the sigmoid flexure in a boy of three with congenital megacolon (Fig. 109). Difficulty with evacuation of the bowel may start with birth or may only become apparent later. Dyspnoea, circulatory embarrassment and compression of the ureter with ensuing hydronephrosis have been observed in the course of the disease (Rankin). If any doubt exists concerning the nature of the abdominal enlargement, the administration of a barium enema or careful inspection of the scout film of the abdomen will serve to set the examiner aright.

D TREATMENT

No treatment is wholly satisfactory. In the presence of acute intestinal obstruction, colostomy is the method of choice. These cases constitute a serious surgical problem because the removal of a single fecal tumor and the reestablishment of the continuity of the intestine do not rid the patient of his disease. Even excision of the enlarged colon does not insure permanent relief. Where the disease is confined largely to the pelvic colon primary resection with reestablishment of intestinal continuity by oblique end to end anastomosis is the procedure of choice. When the entire colon is involved complete extirpation with anastomosis of the terminal ileum to the suprapertoneal portion of the pelvic colon as recommended by Mirizzi, though a formidable undertaking is the only hope for complete relief. The writer has performed this type of operative procedure successfully in a few patients with multiple neoplasms in the colon. A persistent fecal fistula on the abdomen of course will also free the patient from his intestinal stasis in Hirschsprung's disease.

The results reported after sympathectomy for idiopathic dilatation and hypertrophy of the colon have been most encouraging and are, without doubt, the best which have been obtained to date. Rankin and Learmonth have suggested division of the presacral nerve as a satisfactory substitute for the bilateral lumbar sympathetic ganglionectomy of Adson. It is questionable however whether the results from this procedure warrant the substitution. In the procedure of Adson as well as that of Royle, the sympathetic influence to the lower extremities is removed as well—to be certain an unnecessary but yet not an undesirable feature. In patients

juncture of the pelvic colon and rectum may give rise to a mechanical obstruction and subsequent dilatation of the intestine above. The cases which sympathectomy had been performed by Wade and Royle, Addison, Rankin, Robertson, White and others suggest that such a mechanism may operate in certain cases.

Finney, who has given the disease considerable study, inclines to the belief that lymphangiectasis plays an important role in the genesis of the disease. An unusual hypertrophy of all the layers of the bowel, especially



FIG 108—Megacolon in Hirschsprung's disease (There was no mechanical obstruction present) (A. W. Addison, Surgery 1860 1937)



FIG 109—Sigmoid flexure in a boy three years with congenital megacolon (Hirschsprung's disease)

the muscular layer, obtains. In one third of the cases, according to Finney, this enlargement is confined solely to the pelvic colon, in 15 per cent, the entire colon is concerned and, in a few instances, portions of the small intestine have been involved. The writer once observed the condition at a necropsy upon a newborn—the wall of the entire pelvic colon being considerably thickened.

B. PATHOLOGY

Acute intestinal obstruction may at any time be superimposed upon the more chronic picture of intestinal stasis. Volvulus of the sigmoid flexure in congenital enlargement of the colon is not infrequent (Weeks). The obstruction is of the simple variety in most instances, fecal accumulation in the bowel causes a progressive dilatation of the entire intestine above. The accumulation of feces in the bowel may frequently lead to a complete mechanical block. Berry has reported the instance of the accumulation of hard fecal masses in the bowel causing intestinal obstruction in which the

distension was so great as to lead to perforation and peritonitis. In some cases, an associated tuberculous peritonitis brings about the presence of fluid in the peritoneal cavity. The essential pathologic changes in the bowel are hypertrophy and dilatation. The bowel may assume enormous proportions.

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who are poor risks, the retroperitoneal unilateral procedure of Royle is best borne. Resection of the left ganglionic chain and of the presacral nerve is occasionally quite adequate. Adson (1937) has reported the late results in a group of cases of Hirschsprung's disease treated by sympathectomy. In the main, the results were very gratifying. Scott and Morton suggest taking x-ray films following the administration of a barium enema, spinal anesthesia is then induced and roentgen films are again made. A favorable result may be expected to attend sympathectomy if the film following spinal anesthesia shows considerable reduction in calibre of the colon.

In a recent communication, Adson (1941) states that he has been employing, largely, the same type of sympathectomy which he has used to advantage in the surgical management of hypertension. A bilateral subdiaphragmatic approach is employed through which the splanchnic nerves are resected, a portion of the celiac ganglion removed and the upper two lumbar ganglia. This procedure, according to Adson, interrupts the sympathetic fibers which descend along the colon and enter the presacral plexus of Havelock as well as sympathetic fibers which follow the mesenteric arteries to the colon. Concerning the results of operation, Adson states:

- "(1) Sympathectomy of the extensive type, is more effective than the bilateral lumbar, presacral or the intramésenteric sympathectomy.
- (2) If sympathectomy is to be instituted it should be performed preferably before the fifth year of age, before the intestine enlarges beyond the point of recovery. There is no question that, if the intestine continues to dilate and fibrosis and hypertrophy result many of the intramuscular nerve cells of Meissner and Auerbach are destroyed, as are the connections with the parasympathetic and sympathetic nerves which innervate the bowel, an occurrence which makes neurogenic procedures useless."

With the aid of hot water enemas, Friedell has been able to show upon patients on the pediatric wards of the University of Minnesota Hospitals that, the bowel can be made to contract down in instances of megacolon, assuring more effectual evacuations. These daily rectal instillations of hot water should be an integral part of the medical management of such cases.

Law (1940) reported successful management of megacolon with mecholyl bromide (acetylbetamethylcholine bromide). Law looks upon Hirschsprung's disease as the result of an imbalance of the autonomic stimuli to the colon. Two neurogenic hypotheses are possible to explain the occurrence: (1) overactivity of the sympathetic nervous influence, causing inhibition of the colonic musculature with spastic sphincters, (2) diminished toxins of the parasympathetic innervation with resultant ineffectual colonic contraction. Since the papers of Law, Barenberg and his associates (1941) have reported striking success with mecholyl bromide in a patient upon whom a previous sympathectomy had been done without effect. One milligram of mecholyl bromide is given to start with and with increased tolerance a dose of 200 mg. was given twice a day. Mineral oil is given until regular bowel movements are obtained.

In their recent monograph, Ladd and Gross (1941) state that it is their

impression that parasympathetic stimulants, such as mechoyl bromide have a limited field of usefulness, being especially helpful in the mild cases. They emphasize the value of rectal dilators in reawakening the reduced sensitivity of the rectum to distension.

White (1941) believes that adequate medical measures, supplemented by the use of mechoyl bromide will take care of most cases satisfactorily, and that, sympathectomy is to be reserved for the refractory cases. Adson concedes that some of the patients for whom he has performed sympathectomy have come eventually to partial colectomy. The relative safety of extensive colectomy performed as a one stage procedure employing the closed anastomosis in practiced hands, is so well established as to suggest that failure of medical means or sympathectomy is an indication for colectomy.

The results obtained by Perthes, Læwen, and others by division of Houston's valves suggest that the condition of these rectal mucosal folds is always to be ascertained on proctoscopic examination.

Before any operative procedure of magnitude is contemplated upon a patient with megacolon it is important to get the colon empty. It may take weeks before the fecal masses in the colon come away. The liberal daily administration of mineral oil by mouth, daily enemas and instillations of oil into the rectum are necessary to bring this about. David reports an instance in which 47 pounds of feces were found in the large bowel. Colostomy may have to be performed as a temporary expedient. Ask-Upmark has recently reviewed the end results of a group of cases of megacolon treated in Swedish hospitals over a period of time varying from 1 to 25 years. The results in the conservatively treated group were better than in those treated surgically. There were however no sympathectomies in the group. In a review of the results of surgical treatment, Neugebauer points out that the multiple stage resection (exteriorization of Bloch-Mikulicz) commands the lowest mortality. Resection of the colon with reestablishment of intestinal continuity fails to cure uniformly, for, in a number of instances the rectum also is involved (Ask-Upmark). Neugebauer warns that in opening the abdomen of patients with megacolon, care should be taken of the bladder, for it too may be enlarged. Passler (1938) has summarized in a monograph the results of all types of treatment for megacolon.

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In those instances where the distension and the obstructive features are great recourse should be had to operation. In the accompanying skiagraph is shown such an instance (Fig. 110). A multiparous woman late in the seventh month of her pregnancy was admitted to hospital because of abdominal pains and distension—the latter was great as evinced by the film (Fig. 110). The presence of intestinal colic was readily made out. Whether the pregnant uterus compressed the pelvic colon and gave rise to the obstruction, or whether the ileus was spastic in character or due to an intrinsic neoplastic stricture in the bowel could not be ascertained. It was obvious, however, that relief from the distension was necessary to obviate perforation of the bowel. The assumption of the knee-chest position by the patient did not alleviate the intestinal colic—the thought being that the uterus might be tilted forward by this maneuver. A transverse colostomy was done as depicted in Fig. 50. The distension was too great to permit examination of the pelvic colon. Premature labor was induced by the operative procedure and a viable baby was obtained. A barium enema made during convalescence failed to reveal a lesion in the pelvic colon and the glass rod beneath the bowel at the site of the colostomy was withdrawn. Spontaneously the bowel gradually retracted within the abdomen (Fig. 111). The abdominal wall is strong and there is no evidence of hernia.

One can now be certain that there was no intrinsic occlusion in the bowel. Whether this obstruction was due to mechanical compression of the uterus or a physiologic spastic obstruction one can not be wholly certain. Fatal obstruction due to perforation of the colon, occasioned by an annular carcinoma during pregnancy has been reported. A large number of papers have been written upon obstruction in pregnancy. That the pregnant uterus near term can compress the pelvic colon is both affirmed and denied. In instances of the sort referred to above another alternative would have been to empty the uterus at operation by Cesarean section. Should an intrinsic lesion have been present in the bowel however the obstruction would not have been relieved by emptying the uterus alone. The simpler operation of colostomy would appear to be the procedure of choice in such instances. In the presence of sanguineous fluid in the



FIG. 110.—Intestinal obstruction during pregnancy. The fetus, the distended colon and the duodenal tube in a somewhat distended stomach are shown. The small intestine was not distended. The problem to decide was whether the uterus by compression caused the obstruction or whether spastic ileus of the colon or an intrinsic obstruction (probably carcinoma) was responsible.

CHAPTER XVI

INTESTINAL OBSTRUCTION DUE TO COMPRESSION OF THE BOWEL

A PATHOGENESIS

OBSTRUCTION of the intestine by external compression may occur through a number of agencies. Where the bowel is fixed, this type of obstruction is most likely to occur. It is most frequently seen in (1) the pelvic colon, (2) the retroperitoneal duodenum, and (3) the terminal ileum at its insertion into the cecum. Malignant tumors of the pelvic organs and inflammatory masses in the pelvis most often give rise to intestinal obstruction of this variety. The bony boundaries of the pelvis account for the frequency with which this type of obstruction is observed. The "plaster of Paris" induration causing colonic compression in parametritis and cellulitis of the pelvis is well known. Cysts and solid tumors in the mesentery, wandering spleen, hydronephrosis, tumors of the kidney and the pregnant uterus have been known to cause obstruction of the intestine through this mechanism (Ludwig). Tumors of the mesentery, that fix the intestine, permit the bowel becoming squeezed by a small mass which a larger mass would fail to accomplish, if the bowel were mobile enough to escape. The compression of the retroperitoneal portion of the duodenum by the superior mesenteric artery may give rise to the so-called "arterio-mesenteric ileus." The drag of a fat-laden mesentery and a heavy bowel over the duodenum may compress the immobile duodenum against the spinal column. When the patient lies supine or stands erect, this pull would be greatest. As Dwight has pointed out, such an occurrence is not likely in a four-legged animal in which the superior mesenteric vessels would fall forward free from the duodenum.

Large retroperitoneal tumor masses as observed in Hodgkin's disease or metastatic tumors of the testis occasionally give rise to intestinal compression in which mechanical and inhibitive (paralytic) effects commonly operate together.

B PELVIC OBSTRUCTIONS (PREGNANCY)

These obstructions are usually of the simple variety. Compression of the pelvic colon could bring about the effects of an intrinsic obstruction with great increase of intraluminal pressure with consequent threatened perforation of the proximal colon. In the main, however, such obstructions are usually incomplete in nature, and they participate in the features of similar intrinsic obstructions of the colon. A mass can invariably be palpated. In suitable areas the removal of the mass is the operative procedure of choice. The difficulty which arises in distinguishing spastic obstruction of the colon from an intrinsic lesion in the colon may also obtain here.

B ACUTE GASTRIC DILATATION

It is well to remember that acute gastric dilatation can occur with apparently little cause and may be provoked by a variety of diverse agents. It is not uncommonly observed following hyperextension of the spine for reduction of compression fracture of a lumbar vertebra. So frequently has this complication attended fixation of the spine in hyperextension in a plaster of paris cast that suction is routinely applied to an indwelling duodenal tube in this clinic to preclude its occurrence,



FIG 112—Acute dilatation of the stomach—largely gaseous. A X ray film taken directly after the insertion of the gastric tube and before suction was begun shows the stomach greatly dilated. B Film taken after suction had been in force for 2 hours during which time 1000 cc of fluid and 3000 cc of gas had been removed by suction.

as soon as the fracture has been reduced. Whether compression of the duodenum by the superior mesenteric artery in this hyperextended position has anything to do with the frequent supervention of acute dilatation of the stomach is problematic. That this position favors the development of arteriomesenteric ileus is readily apparent. In the prone position, the transverse colon and small intestine fall forward and there should be less likelihood of its occurrence. After trivial trauma, in uremia, diabetes and other conditions acute gastric dilatation may occur with unaccountably little provocation. After thoracoplastic operations on the chest wall, acute dilatation of the stomach occurs, not uncommonly. Hurrying of the pulse and quickened and labored respirations attended by great gaseous distension of the upper abdomen suffice to suggest its presence. Employment of suction will ordinarily rectify matters in a short time. If the nature of the condition remains unrecognized and the distension is not relieved death usually occurs. At postmortem the only significant finding may be a stomach tremendously dilated with gas and fluid.

Postoperative acute dilatation of the stomach has come to be a rare complication with general employment of suction applied to an indwelling

peritoneum suggesting a strangulating obstruction, preliminary emptying of the uterus by Cesarean section probably would be necessary to afford adequate visualization of the nature of the obstruction. Where compression is due to a radiosensitive tumor, the employment of irradiation accompanied by suction applied to an intubing duodenal tube may suffice to avoid operative intervention.

C ARTERIOMESENTERIC OBSTRUCTION

Vomiting is a prominent feature of arteriomesenteric obstruction and dehydration and dechlorination are likely to attend it. The diagnosis is made by the finding on x-ray examination of a dilated duodenum. Pain is

ordinarily not a prominent feature. Every patient with a dilated duodenum does not have arteriomesenteric ileus. Patients suffering from this disorder are subject to periodic attacks of vomiting.

This condition is probably closely allied to so-called acute dilatation of the stomach. The persistent vomiting occasionally observed after operation or after the application of a plaster cast to the body may have its origin in some such mechanism. Suction applied to an intubing duodenal tube and the liberal paroral administration of saline solution will suffice to take care of the acute disorder. For those few cases with frequent such periodic attacks, in whom the duodenum can be shown to be dilated and no other cause can be ascertained, the operation of duodenojejunostomy, first

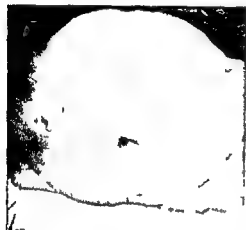


FIG. 111.—Spontaneous closure of colostomy after decompression for acute colonic obstruction. When a barium enema failed to reveal the presence of an organic lesion in the pelvic colon the glass rod was withdrawn and the bowel retracted into the abdomen. (Photograph of patient whose x-ray film is shown in Figure 110.)

performed by Staveley, is justified. When done on good indication, the results are excellent (Wilkie). The operation of partial colectomy to diminish the pull of the superior mesenteric artery and its mesentery upon the retroperitoneal duodenum would not appear to be justified unless the simpler procedure of duodenojejunostomy was ineffectual. (Blood good.)

Since Ladd has pointed out that cases of extrinsic obstruction of the duodenum are due to adhesions and may be relieved by their division, duodenojejunostomy, for so-called arteriomesenteric ileus, is performed relatively infrequently. Undoubtedly many patients operated upon for arteriomesenteric ileus have had the syndrome of Ladd of extrinsic compression of the duodenum by adhesions. Intrinsic duodenal obstruction (duodenal stenosis) presents a proper indication for duodenojejunostomy—a condition that is relatively infrequent as contrasted with extrinsic compression.

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catheter during the early postoperative period. Yet, the potential for its occurrence is ever present. A frequent cause of shock, in debilitated patients, is the fluid loss and hypochloremia of acute gastric dilatation. In experienced house officers are not likely to think of this complication as a possibility when called to the wards to see a patient in shock, drenched with perspiration and exhibiting a thready, hurried pulse, depressed arterial blood pressure and cold extremities. A more seasoned observer is often able to make the diagnosis of acute gastric dilatation in such instances over the telephone in the absence of any external hemorrhage or likely source for internal bleeding much to the dismay of the surprised house officer. Aspiration of the stomach and the liberal intravenous administration of physiologic saline solution in such instance, will quickly revive such patients, much in the manner that water will restore the bloom to wilting flowers.

Acute dilatation of the stomach may present itself in two forms. (1) The mechanical compression syndrome, occasioned by the collection of a large amount of gas in the stomach (Fig. 112). This occurrence may be observed in any patient in the early convalescent period and may accompany injury of varying sorts. (2) The dehydration and dechlorination syndrome occurring usually in debilitated patients, causing severe contraction in the blood volume with the resultant picture of shock described above. Surprising amounts of fluid and gas may be aspirated from the stomach in such instances—necessitating change of the suction bottles, each with a 4 liter capacity, before the distension is gone.

It is strange that such patients have frequently no vomiting. However, the upper left quadrant of the abdomen is distended invariably and quite tympanitic on percussion, usually. Alert, experienced surgical nurses familiar with potential complications which may arise on a surgical ward, and often in directing attention to the possibilities of this occurrence, while there is still time to do something about it.

Patients with obstruction at the pyloric outlet from a duodenal ulcer, and even patients with gastric malignancy with pyloric obstruction may be admitted to the emergency ward exhibiting this syndrome of dehydration and dechlorination. In such instances, the vomiting tells the tale and the cause is obvious. In the cases with acute dilation of the stomach, exhibiting the very same effects with gastric retention but no vomiting the complication is not identified so readily. Moreover, the causes which operate to bring the situation about are frequently obscure or wholly inexplicable.

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CHAPTER XVII

INTESTINAL OBSTRUCTION DUE TO ADHESIONS AND BANDS

A PATHOGENESIS

IN EVERY series of cases of intestinal obstruction, this group constitutes a fairly large proportion of the total. Of 368 cases of intestinal obstruction reported by Flesch Thebesius from the Surgical Clinic at Frankfurt, 162, or 44 per cent, were due to adhesive bands. Guillaume found amongst 400 cases of intestinal obstruction that 125 cases owed their origin to this agency. There is uniform agreement that most adhesions causing intestinal obstruction develop after operation. Of 162 cases of adhesive ileus reported by Flesch Thebesius 113 cases had previously been operated upon. In cases of adhesive obstruction following operation appendectomy is the most frequent cause of subsequent intestinal obstruction, a large proportion have usually required drainage—44 per cent in the series of Deaver and Ross. Operations on the female pelvic organs rank second as the precursor of postoperative adhesions causing obstruction. It is an interesting fact that there appears to be no direct correlation between the location or presence of the adhesions and the development of intestinal obstruction.

Bryant in performing 297 routine postmortem examinations with the point in mind of determining the occurrence of adhesions, found that the transverse colon in both male and female was most frequently involved. Next in frequency, adhesions were found around the gallbladder, duodenum, omentum, ascending colon, hepatic flexure, appendix, liver and descending colon.

Adhesions that give rise to intestinal obstruction may be of congenital origin as the avascular fold that binds the terminal ileum to the cecum. Peterson has devoted an entire monograph to this type of obstruction which he has dignified by the designation "*ileus ilei terminatus fixati*." Adhesions may form also in consequence of external blunt trauma or following intraperitoneal hemorrhage and other inflammations of all varieties and following tumor implants in the abdomen. Adhesions after endometrial transplants in the pelvis are not infrequent. The adhesive type of tuberculous peritonitis commonly causes chronic intestinal stasis and occasionally acute intestinal occlusion. Muller and Rademaker stress the item of infection as being important in the genesis of all adhesions. Kaufman classifies adhesions as postoperative and spontaneous and recognizes amongst the latter division, traumatic, congenital and inflammatory. Many discussions as to whether adhesions are congenital or acquired have generated more heat than light.

Adhesive bands may cause obstruction by actual compression of the bowel through traction and kinking of the intestine or by effecting a

volvulus or strangulation of the bowel Meckel's diverticulum may give rise to obstruction by any one of these mechanisms Bands causing intestinal obstruction usually concern the small intestine, when the large intestine is involved, the flexures of the colon are usually implicated—the hepatic, splenic, and sigmoid flexures Colonic obstruction by adhesions is usually due to compression, such as a band running from the stomach over the transverse colon becoming adherent to some other fixed point In the experience of the writer obstruction of the colon is rarely brought about by adhesive bands Bucermann believes that pericolic bands overlying the right colon may cause pains, simulating appendicitis McCann has described recently instances in which he believes that the omentum gave rise to colonic fixation and obstruction The bands may be narrow, representing mere threads or they may be broad peritoneal folds In the 125 instances of adhesions reported by Guillaume, 65 cases were of the former variety and 60 of the latter type

Intestinal obstruction through the agency of adhesions may occur at any time after operation Of the 113 cases of postoperative ileus in the series of *Flesch-Thebesius*, 69 followed appendectomy Of these, 25 cases developed in the first four weeks after operation, 20 others occurred within the first year, 8 in the second year, 5 in the third year, 5 in the fourth and fifth years, 5 in the sixth to tenth years, and one occurred later In the cases of *Denver* and *Ross*, the average time after operation for the development of obstruction was two years and three months Foreign bodies left in the peritoneum are a great stimulus to the formation of adhesions which may cause obstruction

II PATHOLOGY

Adhesive bands may give rise to either a simple intestinal obstruction or to the strangulating variety The more frequent occurrence is the simple occlusion of the lumen by compression, kinking or traction Volvulus is not infrequent through the medium of abnormal bands in the peritoneal cavity Wilms has described this variety of intestinal obstruction in considerable detail under the special caption of "Knotting of the Small Intestine" Kallio has recently devoted a monograph to this particular variety of obstruction which he found more frequent in Finland than elsewhere In those instances in which the vitello intestinal duct persists as Meckel's diverticulum in the adult and especially where the obliterated vitelline vessels run out to the umbilicus as a cord like structure such bands may not infrequently give rise to strangulation or kinking of a loop of the intestine In the postoperative period, particularly if distension is present fibrinous adhesions and inflammatory processes are likely to kink and obstruct the bowel The same holds true of conditions arising spontaneously in which the presence of blood or pus in the peritoneal cavity brings meteorism about and at the same time gives rise to the formation of fibrinous adhesions The writer once observed the occurrence of adhesive obstruction through the agency of hematoma formation occasioned by torsion of aberrant (accessory) splenic tissue

C CLINICAL FEATURES

The symptoms of adhesive ileus vary within the widest possible limits, depending largely upon whether the obstructive mechanism is simple in type or of the strangulating variety. It is also obvious that varying grades of both types may be present. Intermittent crampy colicky pain is usually the patient's first complaint. Nausea and vomiting soon follow. Tenderness is not present unless the adhesive band becomes adherent to the abdominal wall exerting traction on the parietal peritoneum. If an intestinal loop is strangulated, sanguineous fluid escapes into the peritoneum producing tenderness.

The history of a previous operation is often very significant in arriving at an opinion. In such instances frequently the diagnosis can be made over the telephone as the late Lord Moynihan characterized the case of recognition of typical cases of duodenal ulcer. When the surgeon is informed that his patient is suffering from gas pains and that nausea and vomiting are prominent features that the abdomen is distended but not tender and that minor disturbances of a similar sort have been present now and then since an appendectomy or hysterectomy performed a few years ago the surgeon should suspect bowel obstruction. It is not to be forgotten however that adhesions may obstruct and strangulate the bowel in the absence of abdominal operative scars.



FIG 113.—Adhesions demonstrated by inflation of carbon dioxide into the peritoneal cavity. This procedure was done after relief of acute intestinal obstruction by enterostomy.

Richardson has stated that 2 per cent of the patients having suppurative appendicitis requiring the employment of drainage upon whom he has operated have had pain of an obstructive character during their convalescence. Grey Turner states that out of 2500 operations for appendicitis 45 cases or 1.9 per cent subsequently develop acute adhesive obstruction of the small intestine.

D DIFFERENTIAL DIAGNOSIS

That mechanical obstruction is present is the most important thing to decide. To be certain one can rarely be wholly certain that the obstruction is due to an adhesive band or multiple adhesions. In the distension occurring early in the postoperative period a functional obstruction has to be excluded. The stethoscope affords the most reliable evidence in this differential. A mechanical obstruction without *intestinal colic* does not exist. The x-ray film also lends important information when correlated with the clinical findings. In typical instances, the roentgenologist fre-

quently can tell whether the obstruction is mechanical or functional (paralytic). Intestinal distension, however, is subject to so many interpretations, made on the basis of the extent of the intestinal distension and the conjectured absence or presence of fluid between distended intestinal coils as viewed on the x-ray film are open to errors. When a loop of bowel has been imprisoned beneath an adhesion for some time, the picture of stenosis may appear—palpable visible peristalsis of the hypertrophied and distended loops of gut in evidence. In such instances, the diagnosis of neoplasm of the intestine is made usually.

The development of a mechanical obstruction during convalescence from operation is, it is true, most likely to be due to adhesion formation. However, the presence of a potential obstructing agency, not previously recognized, such as a carcinoma of the bowel, must always be thought of. Volvulus has occurred during the convalescence from operation. Herniation of the gut into the lesser omental bursa after gastropyloroplasty beneath the jejunal limb, leading to and away from the stomach or a fixation of the fixed colon after colostomy have been reported. Such accidents must be kept in mind in deciding upon the nature of a postoperative obstruction. Multiple obstructions have been described (Finsterer, Block, Selfer, see p. 439).

E TREATMENT

Early recognition is the best treatment. A large number of obstructions due to adhesions will respond to suction siphonage. This is particularly true of the partial obstructions and those occurring as a complication of an accompanying inflammatory process. The application of hot packs to the abdomen and the administration of hot douches and enemas are of value in hastening the resorption of inflammatory masses. Adhesive obstructions occurring during convalescence from an antecedent abdominal operation almost uniformly yield to suction. As has been pointed out (p. 169), the avoidance of distension during the early postoperative period by the routine employment of suction in those instances where occurrence of distension is to be anticipated, will very materially diminish the incidence of the postoperative mechanical obstructions. The instructions outlined on page 153 should be carefully followed in the conservative management of such cases.

In the patient whose obstruction needs relief by operation, the general status of the patient and the local abdominal physical findings should guide the surgeon. A strangulating type of obstruction calls for an exploratory vertical incision and determination of whether the bowel is viable. For the late simple obstruction, enterostomy is the operative choice, in the early simple obstruction the operation of election may be done with deliberate search for the point of obstruction. Summer's will invert satisfactorily a small damaged area of bowel beneath a constricting band (Fig. 114). A single adhesive band is dealt with much more easily than multiple ensnaring adhesions. In the instance of the forerunner of simple division is in order, in the latter, a note of warning is to be sounded against the direct attack of attempting their release. Frequently the unsuspecting surgeon is lured on by the chase of adhesive bands, like

innocent children of Hamelin were carried off by the Pied Piper, until he finds that there is no retracing his steps. He has enmeshed himself in the entanglement and escape without doing harm may be unlikely. Too often the bowel is opened, which accident in the presence of obstruction usually spells doom for the patient. A simple enterostomy in such instances will save the surgeon considerable difficulty and multiply the patient's chances of recovery. Should the enterostomy vent prove to be the only avenue of escape for intestinal content and the intestinal lumen below continue



FIG 114—Method of inverting a small gangrenous area in the gut wall (so called Summers stitch) (See also Fig 102 illustrating technique of removal of gallstone) (a) Placement of Halsted mattress sutures. It is to be noted that the suture at either end is what the writer describes as the 3/2 stitch. That is in order to insure satisfactory closure at the ends the stitch going takes 3 bites of tissue and 2 returning. This 3/2 stitch takes the place admirably of a semi-purse string suture and one can predict reasonably the character of the inversion which attends its use. (b) The suture completed.

obstructed a subsequent attack will have to be directed at the obstructing agency. When the patient exhibits definite improvement from the decompression such a succeeding procedure when feasible should be release of the gut from the entangling adhesions occasionally however an entero-anastomosis or even resection of this segment of gut will have to be made. In the main entero-anastomosis is a safer procedure. The warning uttered by Estes and Holm and Pearce and others relating to distension of such a side-tracked loop must be borne in mind. Usually however, in adhesive obstructions as well as in stenosis demanding an entero-anastomosis though a sufficient lumen does not exist for drainage of the entire intestinal current the shunting accomplished by the lateral anastomosis enables the lumen of the obstructed gut to drain this short segment of bowel adequately. There is an occasional case of obstruction due to a single adhesive band, in which the performance of "blind enterostomy"

does not suffice to deal with the situation. Despite the decompression of the distended bowel by the enterostomy catheter, the adhesive band may cut into the lumen of the bowel, causing leakage and peritonitis. The writer has had such an experience. The potential for this occurrence suggests the necessity for developing means, whereby the bowel can be decompressed safely at operation. It was just such an experience which suggested to the writer the elaboration of a safer method of emptying the bowel at operation than is afforded by the Monks-Moynihan evacuating tube. Diminution of the distension, brought about by removal of the contents of distended intestinal loops in the vicinity of the obstruction, permits accurate identification of the nature of the obstructing mechanism and enables the surgeon to determine the safe choice of procedure in dealing with the band. Aseptic decompressive suction enterotomy (see Fig. 53B) constitutes a satisfactory means of dealing with the distension in such instances. Simple enterostomy is a good operation, but it does leave a good deal to chance, occasionally.

In this clinic, a number of partial enterectomies have been done upon patients, in an unobstructed phase, for recurrent obstruction, due to adhesions. *It is often the best solution for the patient, preventing an enlarged snarl of adhesions and who has been obstructed several times* (see page 211).

When operating for adhesive obstruction, the site of a previous operation should be carefully inspected in suitable cases. It is wise to select a fresh area over the abdomen for the incision. Too frequently the gut is adherent to the abdominal wall immediately below the old scar. The presence of hemorrhagic fluid suggests the necessity of looking for a strangulating obstruction. Rarely a simple obstruction may cause sanguineous fluid to accumulate in the peritoneal cavity. The surgeon is never disappointed upon completion of his search to find that the obstruction is simple in character. When circumstances permit and occasion demands it a routine examination of the entire small intestine must be made to rule out an obscure but persistent band which may prove a menace later.

The tendency to formation of peritoneal adhesions appears to be in some measure an individual factor. Occasionally they form in abundance after so-called "clean" or interval operations and in other instances may fail of being demonstrated after fairly diffuse peritonitis. Intraperitoneal ligations 'en masse' the introduction of chemical irritants and the use of too hot abdominal packs predispose to their occurrence. Horne believes that adhesive ileus is much more likely to follow when drainage is established through midline or rectus incisions. Encirclement of the drainage tract by loops of the intestine is much more likely. Horne states that when lateral drainage is established. Following pelvic operations, a definite attempt should be made to peritonealize all raw areas, the sigmoid flexure often serves this purpose well.

Operation is well deferred when feasible in patients preventing the effects of a simple adhesive obstruction who are convalescing from a peritoneal infection, such as peritonitis attending rupture of the appendix. Too often, exploration, enterostomy or any procedure, succeeds only in spreading the infection, thereby intensifying the obstructive element. Suc-

tion applied to an indwelling duodenal tube, if effectual is usually the best attack upon the obstruction in such cases. Nevertheless, the surgeon must bear in mind in such instances, the possibility of a strangulating obstruction, which must not be treated by suction alone. Some of the difficulties which hedge about this problem have been discussed previously (p. 115).

In this clinic, two women presenting intestinal obstruction, occasioned by plastic pelvic masses, were treated successfully by a combination of suction and the application of external heat with the Kettering hyperthermic apparatus (Smith). The improvement in both instances was striking. This agency may prove helpful in deferring the necessity for operation in plastic inflammatory masses.

Prevention of adhesions

The formation of intraperitoneal adhesions is a reparative process in response to injury of a serous surface. The problem as it relates to adhesions is not so much one of prevention as of limiting this process of repair during the healing stage to the injured endothelial membranes. Of the large number of substances that have been recommended to prevent the formation of adhesions and have been given adequate clinical trial very few have withstood the test of time. Essentially four types of agents have been employed to obviate excessive intraperitoneal adhesive formation. (1) The application of greasy or oily substances over the denuded peritoneal surfaces, such as liquid paraffin, vaseline or acacia. The testimony of experimental evidence would indicate that these remedies stimulate rather than prevent the formation of adhesions. (2) The administration of drugs such as eserine, pituitary extract, prostigmine and others to augment intestinal activity in the immediate postoperative period. (3) Introduction of dilute solutions of tissue digestants such as pepsin, trypsin or papain into the peritoneal cavity. (4) The use of fluids which are slowly absorbed from the peritoneum. In the ascitic variety of tuberculous peritonitis adhesions are rarely seen. Saline and sodium citrate solutions are absorbed too quickly to be of any great value in floating the intestinal coils apart during the healing period. Amniotic fluid has been used for this purpose with varying results by a number of investigators. Rea and Wangenstein found a 1 per cent solution of sodium ricinoleate (soap solution) more effectual experimentally than amniotic fluid, defibrinated blood, or air. Lehman and Boys (1940) find that heparin destroys and inhibits fibrin formation when placed in the peritoneal cavity. They believe that heparin may come to play an important role in preventing adhesion formation.

It is difficult to appraise the true value of clinical reports which indicate the lessened incidence of bowel obstruction due to adhesions following the use of one agency or another. In assaying the value of any method a crucial test is presented by those patients who are 'adhesion formers'. The writer's experience with a limited trial with anti-adhesive agencies in such patients would indicate that too much optimism has been expressed by many writers concerning the prevention of adhesions.

There are a group of patients who have had a long series of abdominal operations for adhesions and bowel obstruction which present a very

difficult problem. In recently looking up the cases of this nature which the writer has treated, it was found that the majority of them were morphine addicts—probably made so by a low tolerance to persistent pain. It appears to the writer that morphinism is probably an important factor in the difficulties of these patients. Some of them have come in complaining of gas pains and vomiting when gaseous distension of the small intestine was absent altogether or scarcely recognizable in the roentgen films. Constipation has usually been an important feature as well and it has been difficult to escape the impression even though intestinal colic could be demonstrated that the functional element was not perhaps even as important as the adhesions. Some of these cases are undoubtedly closely allied to so called functional spastic ileus. The hope of re operation with the combined use of agencies to prevent adhesion formation would not appear to be very promising in such instances.



FIG 115—Pneumoperitoneum after enterolysis to prevent adhesion formation between anterior abdominal wall and the intestines. The patient's buttocks are kept elevated for several days on pillows as shown.

buttocks were kept elevated on two or three pillows with the thought in mind that the air would accumulate largely between the intestinal loops and the anterior abdominal wall (Fig 115). This maneuver it was believed, would obviate adhesion formation between the intestines and the anterior abdominal wall. The first patient upon whom this procedure was carried out had been operated upon thirty times for intestinal obstruction. The patient had once been a student nurse in training. The writer did her thirty first operation. It was learned subsequently that she was a morphinist. No subsequent operations for obstruction have been necessary, but the patient has been admitted to hospital for brief stays of a few days on several occasions when she complained of gas pains. Intestinal colic has not been definitely present on any of these occasions and gaseous distension of the small intestine has been absent. Yet, immediate relief has been afforded by the application of suction to an invlving duodenal tube. On one of these entries, an attempt at carbon dioxide inflation of the peritoneum was made to see whether a free peritoneal cavity was present. Multiple adhesions were again present. After the lapse of more than ten years, she declared herself well and free from morphinism, if her statement is to be credited.

In a group of this type who presented definite evidence of obstruction the writer, a number of years ago, performed enterolysis of the entire small intestine after initial decompression by suction. Universal adhesions are the rule in such instances. Before closure of the abdomen about 1000 to 1500 cubic centimeters of air was run in with the aid of sterilized bottles and tubing used for purposes of introducing pneumothorax. During the convalescent period these patients'

No such air inflations have been done in recent years after enterolysis in the unobstructed phase. The writer has come to feel that, partial enterectomy, in suitable cases, with sacrifice of that segment of gut involved in the adhesions is the better procedure. A number of patients have been treated successfully in this manner.

The writer has come to know either through correspondence or in consultation with surgeons throughout the country, of a number of patients who have had multiple operations for adhesions. Dr. Hans E. Schiffbauer at the Los Angeles County Hospital in California showed the writer two such patients, who were habitués of the hospital. Both were nurses and both were morphinists. Both patients had had a large number of operations. Suction applied to an indwelling duodenal tube has come to be a great boon to such patients, in avoiding the necessity for further operation.

In patients observed in more recent years, who have had multiple operations for adhesions, causing obstruction, the writer has observed some who have been operated upon principally because of vomiting, in whom the obstructive symptoms of *intestinal colic* had not been prominent. Several of these patients have exhibited histamine achlorhydria and have had a low basal metabolic rate. Improvement has attended the administration of desiccated thyroid, and the vitamin B complex.

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CHAPTER XVIII

INTESTINAL OBSTRUCTION DUE TO EXTERNAL HERNIA

A PATHOGENESIS

THE hernial orifices through which contents of the abdomen may protrude have for the most part hard fibrous edges which quickly compress and strangulate an intestinal loop which makes its way through such a channel. The external orifices at which hernia occurs most frequently are, the inguinal, femoral, and umbilical, these are also the hernias that most commonly give rise to intestinal obstruction and symptoms of strangulation. Less frequently strangulation may be seen in incisional, epigastric, semilunar, obturator, perivesical, lumbar, sciatic, and perineal hernias. Out of 2032 operations for hernia at the Hospital for Ruptured and Crippled, Bull and Coley reported 24 cases of strangulation. The following table gives the distribution of cases of strangulated hernia as noted by their authors.

TABLE XXXVII—INCIDENCE OF THE VARIOUS TYPES
OF HERNIAS IN STRANGULATION

Author	Date	Total number of cases	Inguinal	Femoral	Umbilical	Others
Thorburn	1903	110	55	37	17	1
Erdmann	1904	58	31	19	6	2
Hilton	1907	529	250	250	—	29
Alexander	1913	105	60	25	20	—
Deaver and Ross	1915	156	77	50	21	8

The relative frequency of the different types of hernia and the incidence of strangulation is noted in the following table. Whereas, inguinal hernia is more common, it is apparent that strangulation is relatively more frequent in femoral and umbilical hernias.

TABLE XXXVIII—THE INCIDENCE OF HERNIA AND STRANGULATION

	Date	Total no of cases	Inguinal			Femoral			Umbilical			Incisional		
			No of cases	Per cent	Strangulated Per cent	No of cases	Per cent	Strangulated Per cent	No of cases	Per cent	Strangulated Per cent	No of cases	Per cent	Strangulated Per cent
Beller and Colp	1925	4 139	3 208	77	4.0	294	7.0	3	167	4.0	15.0	377	9.0	3.0
Erdmann	1927	2 567	2 300	89	1.8	97	3.7	95	89	1.1	17.2	143	5.6	5.5

protrudes cramps the content of the sac. In inguinal hernia, the external ring constitutes the more frequent cause of strangulation. Strangulation at the internal ring occurs fairly commonly, and less frequently a constriction in the sac may constitute the strangulating mechanism. Right inguinal hernia is more common than left, and similarly, strangulation on the right side is observed more frequently than on the left. Because of the more gradual development of direct inguinal hernia and the progressive stretching of the hernial orifice, strangulation only infrequently occurs. Femoral hernia ranks as one of the commonest causes of intestinal strangulations (Souttar). When it is remembered that femoral hernia is much less common than inguinal and that the number of cases of strangulation of femoral hernia closely approximates that of the inguinal group, the likelihood of strangulation in femoral hernia is quite apparent. The rigid walls constituted by Poupart's, Gimbernat's, and Cooper's ligaments form a very treacherous aperture when a loop of bowel protrudes itself into it. In consonance with the greater incidence of femoral hernia in women, strangulation also occurs more frequently in the female. The rigid fascial insertions into the linea alba at the umbilicus make for frequent strangulation of the intestine at this site. Not infrequently, however, the omentum precedes entry of the intestine into this orifice by a considerable period of time, and the walls are gradually stretched out so that later, when the intestine (usually the transverse colon) finds its way into this umbilical sac, the walls are somewhat more yielding than previously.

B PATHOLOGY

The effect on the intestine consequent upon being engaged and strangulated in a hernial orifice is much as that observed experimentally when a loop of intestine and its mesentery are tied off. In consequence of interference with the venous return, rapid congestion, edema, and swelling occur. Transudation of fluid into the lumen of the bowel as well as into the hernial sac follows. The fluid in the sac early is clear and sterile. Incident to gaseous distension and fluid accumulation within the loop, progressive changes in the bowel wall ensue as manifested by ulceration of the mucosa, livid appearance of the bowel which progressively deepens until perforation and gangrene follow unless the constriction is released. When the bowel is no longer viable, the fluid in the hernial sac may be bloody or turbid and bacteria can be demonstrated on culture of the fluid. Bacteria may occasionally be demonstrated in the fluid of the hernial sac when the bowel is viable.

In large umbilical, scrotal, and incisional hernias incarceration or obstruction of the loop of intestine in the sac rather than strangulating effects are observed. Under conditions in which fluid accumulates and gas becomes trapped in the incarcerated intestinal coils the pathological changes of strangulation may also be seen.

C CLINICAL FEATURES

The symptoms of strangulated hernia are those of intestinal obstruction with the addition of a painful, tender and often tense swelling at one

of the hernial orifices. When sudden engagement of an intestinal loop by a hernial ring occurs, the pain may be so severe that temporary collapse may follow. The history of patients having been aware of the existence of a hernia is usually obtained, occasionally, however, strangulation may be the first warning of the presence of such a protrusion.

It is first important to determine that a patient actually has a hernia by the criteria one ordinarily employs to demonstrate its presence. In the inguinal region inflammation of the inguinal or iliac lymph nodes must be excluded, in the male, torsion of a normal or inguinal testis should be ruled out. Thrombosis or phlebitis of the veins of the spermatic cord may cause difficulty in diagnosis. In femoral hernia, thrombosis of the femoral or upper portion of the saphenous vein may give rise to confusion. Strangulated umbilical and femoral hernias may simulate local subcutaneous circumscribed infections with intense reddening of the skin over the sac, owing to liquefaction of infarcted fat.

The symptoms of obstruction *viz.*, severe colicky pain, nausea, and vomiting help to establish the diagnosis. The content of the sac can frequently be determined by percussion, a tympanitic note being given by imprisoned bowel. In the presence of considerable exudation into the sac, this note may be dampened somewhat but is never as dull as the percussion note produced by incarcerated omentum. The presence of gut in the sac can frequently be demonstrated by a lateral x-ray film (Fig. 117). A strangulated hernia presents usually considerable tenderness and an impulse on cough can not be elicited. In obstruction or incarcerated hernias, an impulse is present on cough and tenderness is absent or slight.

In patients presenting the symptoms of early obstruction but no evidence of hernia other than tenderness at one of the hernial orifices strangulation of an enterocele (Richter's hernia) must always be given consideration. In this condition a portion of the bowel wall is constricted in a hernial orifice the lumen of the intestinal canal remaining unobstructed. This portion of the bowel may become gangrenous and a fistula may form giving rise to the development of an abscess at the site of presentation. Impingement of a portion of the bowel wall is most likely to occur in small hernial orifices with tendinous margins. The inguinal femoral linea alba (epigastric) and obturator apertures are the common sites for its occurrence. Strangulation of Meckel's diverticulum in a hernial sac is known as Littre's hernia. Sweet has recently collected 14 such cases from the literature. In strangulation of the interparietal variety of indirect inguinal hernia described by Kronlein the swelling and tenderness may be confined to unusual areas paralleling the direction and plane in which the hernia has dissected up over the abdominal wall.

Epigastric hernias usually present peritoneal fat as their only content. Occasionally however the parietal peritoneum is evaginated sufficiently into the aperture in the linea alba to permit engagement of the intestine. In 1914 Moschcowitz stated that 14 instances of strangulated epigastric hernia had been reported and in only 5 of these was there intestine in the sac. Transverse colon is the usual occupant of the sac but

small intestine may also find its way into the pouch. Large epigastric hernias are usually para-umbilical in location.

Pain down the inner side of the thigh as far as the knee (Howship-Romberg sign), corresponding to the sensory distribution of the obturator nerve in a patient with symptoms of intestinal obstruction, is suggestive of the presence of strangulation of an obturator hernia. It is only infrequently diagnosed prior to laparotomy. Vaginal or rectal examination may



FIG. 117.—The presence of bowel in a strangulated femoral hernia detected by x-ray examination. The arrows indicate the ectopic position of the bowel. Only rarely does a roentgenogram add useful information to the diagnosis of strangulated external hernia.

disclose a tender mass above the inferior ramus of the ischium. Watson (1938), in his monograph on hernia, states that 420 cases of obturator hernia are reported. Strangulation is common and the mortality is high. The Howship-Romberg phenomenon was noted in 88 cases. Of 396 cases of obturator hernia collected by Watson, a large number were strangulated.

Fromme (1908) claims to have made the diagnosis of a supravesical hernia by noting bulging of the anterior bladder wall through the cystoscope. Warri and Orr (1940) state that approximately 60 cases of hernia about the urinary bladder are reported in the literature. Of these, 37 are true supravesical hernias. Strangulation is not uncommon. In the cases tabulated by Warri and Orr, the mortality was 44.1 per cent.

Lumbar hernias are occasionally strangulated. Of 115 cases collected by Watson, 13 presented evidence of strangulation.

Strangulation may be the first sign of a sciatic hernia. Watson says that only 30 cases of sciatic hernia have been reported. Pain may be referred down the posterior side of the thigh and tenderness may be demonstrated at the gluteal fold which may in part be obliterated.

Perineal hernias only infrequently give rise to intestinal obstruction of an acute nature (Black).

D. TREATMENT

Perhaps nowhere is better illustrated the success of early treatment of intestinal obstruction than in strangulated hernia. Bower found that the average length of time elapsing between onset of the symptoms and operation for strangulated hernia was 31 hours, whereas, for cases of intestinal obstruction, the same time was 76.6 hours. The latter being greater by 177 per cent. Braun and Wortmann state that 1796 cases of strangulated hernia were seen at the Friedrichshain Hospital in Berlin between the years 1903-

1922, in this group there was a mortality of 280 cases, or 15.6 per cent. In 1509 cases of the entire group no gangrene was present, of these, 136 died a mortality of 9.0 per cent. Of 286 cases of gangrene, 144 died, a mortality of 50.9 per cent. Frankau has recently reported the results of a collective investigation instigated by the Association of Surgeons of Great Britain and Ireland on strangulated hernia. There were 1487 cases in the group, the mortality was 15.7 per cent. In 105 instances, because of gangrene of the bowel, resection was done with 45 deaths a mortality of 42.8 per cent.

The greater ease in arriving at the diagnosis of intestinal obstruction in an external hernia which presents the features of intestinal obstruction naturally accounts for the fact that these patients come to operation sooner than do patients with internal types of intestinal obstruction. The fact that definite local physical findings are present helps very much in determining the presence of bowel occlusion early. The treatment indicated for all strangulated hernias is immediate operation under appropriate anesthesia and deliberate cutting of the band that causes the strangulation. Blood loss, if reflected in the systolic pressure should be replaced by preoperative transfusion. The incision should generally be a little more generous than the usual hernia incision to permit of adequate exposure. A strangulated femoral hernia should be exposed through the inguinal approach above Poupart's ligament. The hernial sac should then be opened and the condition of the bowel ascertained. A turbid or bloody fluid in the sac gives evidence of prolonged vascular impairment. A return of the normal luster of the bowel and pulsation in the vessels is adequate evidence for returning the loop to the abdomen. In instances where the bowel wall presents a ring like area of constriction on one or both limbs of the herniated intestine at the site of strangulation the placement of a few inverting sutures—Summers' stitch of fine silk placed after the Halsted mattress pattern will not only help to avoid immediate trouble from leakage but will also serve to avoid subsequent stricture formation. Fig. 114 p. 351. In instances in which the viability is doubtful the writer favors primary intestinal resection over exteriorization. Primary resection has come to replace exteriorization in dealing with devitalized bowel in this clinic in all types of strangulating obstruction. When the patient is extremely ill simple exteriorization and drainage of the oral loop is the alternative procedure of choice. Whenever possible in such instances it is best to exteriorize through a simple vertical incision—a maneuver which permits of dealing more adequately with the hernia. When the physical status of the patient does not warrant this refinement however it is to be omitted. The hernia itself is to be dealt with by standard techniques. The use of interrupted sutures of silk is an important item in enhancing the chances of permanent cure of the hernia.

The reduction of strangulated hernias by taxis is a method of doubtful value. Unless the patient is seen within a short time of the strangulation taxis is better not attempted. A strangulated non viable bowel has occasionally been reduced when both physician and patient had been of the opinion that the danger was past. Mere reduction of the strangulated hernia by spinal anesthesia is to be condemned unless operation is imme-

diately performed. In his comprehensive report on the value of spinal anesthesia in ileus, Duval refers to several cases where perforations were found in the bowel after reduction. Casten (1941) has reviewed the literature of reduction *en masse* of strangulated hernia. He states that 207 cases are to be found reported in surgical literature. Even though it is strongly felt that omentum is the sole content of the sac, this should be no deterrent to immediate operation.

In operating upon strangulated hernias it is well to bear in mind the possibility of retrograde incarceration. This hernia is frequently described as hernia "en W" (deBeule). A portion of the loop that becomes engaged in a hernial sac may subsequently escape and return into the peritoneal cavity while the remainder of the intestine and the mesentery of the entire segment initially present in the hernial sac continue to be compressed by the strangulating mechanism. The loop that remains inside the peritoneal cavity may be often more severely devascularized than the loop within the sac.

Obturator, suprapubic and sciatic hernias causing intestinal obstruction are best recognized and reduced through a laparotomy incision.

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CHAPTER XIX

INTESTINAL OBSTRUCTION DUE TO INTERNAL HERNIA

INTERNAL hernia is relatively infrequent, at the Friedrichshain Hospital in Berlin during an 18 year period, 1795 cases of external hernia came to operation. Only 21 cases of internal hernia presenting features of obstruction were treated during the same interval of time. Among 400 cases of intestinal obstruction reported by Guillaume, only four concern internal hernia. Of 456 cases of intestinal obstruction reported by Küttner from Breslau, however, 23 were instances of internal hernia.

The sites at which these strangulations may occur are (1) diaphragmatic hernia, (2) hernias of the foramen of Winslow, (3) hernias of the para-duodenal fossae, (4) persistent hole in the mesentery, (5) hernia into the intersigmoid fossa, and (6) pericecal hernias.

A DIAPHRAGMATIC HERNIA

Pathogenesis

In 1925, Hedblom collected 378 cases of diaphragmatic hernia of which 126 or 33.3 per cent were strangulated or exhibited symptoms of acute intestinal obstruction. Patients with intestinal obstruction due to this agency may present themselves at any time of life. Many are congenital, but those necessitating operation for intestinal obstruction are largely the result of trauma. The hernias of congenital origin are to be enumerated as hernia through an abnormal aperture in the diaphragm or hernia through one of the normal foramina of the adult diaphragm. Of these, para esophageal hernia is the most common and usually manifests itself later in life and is frequently present under circumstances that increase intra abdominal pressure (Rigler and Eneboe). Hernias of this sort are rarely strangulated though volvulus of the stomach may occur in such a hernia. The strangulated diaphragmatic hernia of the infant is observed most frequently through the pleuroperitoneal hiatus, an opening which usually is closed by the third month of fetal life. The anterior, lateral and central portions of the diaphragm are formed from the transverse septum and fused ventral mesentery. The remaining postero-lateral portion is formed by the fusion of the dorsal mesentery and the mesoderm derived from the receding Wolffian body and the pleuroperitoneal membrane which comes from the pulmonary ridge. Failure of fusion of these elements at any of their normal points of union may cause a communication to persist at the fetal pleuroperitoneal hiatus.

Crushing injuries of the chest and upper abdomen or stab or bullet wounds that penetrate the diaphragm are the usual cause of the development of traumatic diaphragmatic hernia. In children they are frequently the result of automobile accidents in which the child is run over or is struck forcibly by bumper or fender.

Pathology

The colon is the portion of the bowel that most frequently herniates into the chest and becomes obstructed by the compression of the muscular diaphragm. Any abdominal viscus, however, may be herniated into the chest and any portion of the intestine may be obstructed. Unlike strangulated external hernias in which the compression ring is unyielding and in which gangrenous changes in the bowel occur with frequency, in diaphragmatic hernia these are unusual. The strangulating mechanism being a



FIG 118—Diaphragmatic hernia with symptoms of acute intestinal obstruction (Pleuro-peritoneal hiatus hernia) (a) Antero-posterior film showing large gastric loculus in the thorax. The patient was cyanotic and dyspnoeic prior to employment of suction. (b) Lateral film made at the same time. (c) After surgical repair of the defect. The patient Mr D A aged 27 Univ Hosp No 862347 was operated upon for his second attack of bowel obstruction occasioned by this congenital defect.

muscular ring and capable of being dilated, obstruction rather than strangulation of the bowel occurs initially though devascularization of the herniated bowel may follow unless the hernia is reduced.

Clinical Features

The symptoms of obstruction may occur within a very short time after the receipt of the injury, but ordinarily some time elapses before attention is directed to the serious character of the lesion. Congenital pleuro-peritoneal hiatus hernias have been observed in this clinic in which no suggestion of the presence of the defect became evident until the patient became obstructed in early adulthood. Dyspnoea is not an infrequent complaint due to the compression of the lung by increase in the thoracic contents and may antedate considerably the symptoms of obstruction. Cyanosis has been present in most of the obstructed pleuro-peritoneal hiatus hernias and traumatic ruptures of the diaphragm observed in this clinic. Severe pain is complained of; there is usually nausea and vomiting and tenderness in the upper left abdomen. Intestinal obstruction due to hernia occurs almost invariably through the left diaphragm. Hernia through the dome of the right diaphragm does occur but it is usually the

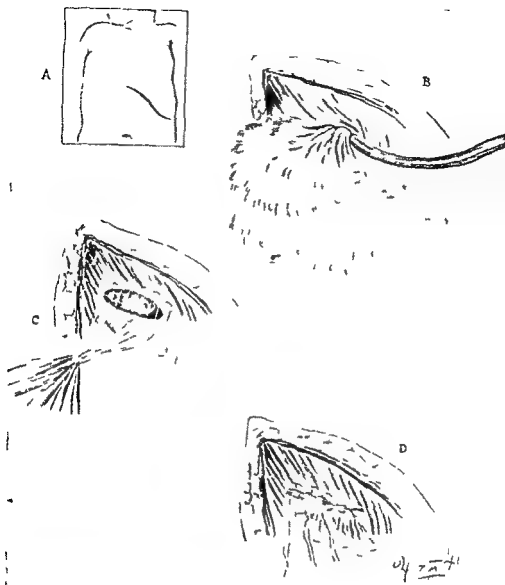


FIG 119—Repair of pleuro peritoneal hiatus hernia in diaphragm (a) The incision (b) The maneuver of the late C. H. Mayo for equalization of pressures in pleural and peritoneal cavities. Injection of air through the catheter into the pleural space causes the intestine to return spontaneously frequently if the abdominal viscera are not adherent in the thorax (c) Placement of interrupted Halsted sutures of silk (about 5 pound test) to close the defect (d) Plan of Weinberg, employing loose perineal fascia to suture over site of closure in instances in which the diaphragmatic closure is not completely satisfactory. If the approximation of the sutures shown in (c) is under tension the phrenic nerve should be pinched with a hemostat along the left border of the heart to avoid tension and motion during the healing period.

liver which enters the pleural cavity in such instances. Among 34 specimens of diaphragmatic hernia in London museums Keith found twice that hernia had occurred through the dome of the right diaphragm. The

defect in each instance was occupied by liver. In his series there were 17 hernias through the left pleuropertitoneal hiatus but only 4 through the right. On examination, a diminished excursion of the thorax on the left side accompanied by impairment of resonance over the chest can usually be made out. Titten's phenomenon is usually absent on the left. Anteriorly, there may be tympany when considerable gas is present in the bowel and, posteriorly, there is ordinarily dullness due to the compression of the lungs. Frequently intestinal borborygmi and intestinal gurgling sounds may be heard over the chest. Gibson calls attention to the diagnostic significance of cardiac displacement occasioned by the shift in the position of the mediastinum. An x-ray film of the abdomen and chest will show the presence of gas above the diaphragm (Fig. 118). A barium enema may likewise demonstrate the presence of the colon above the level of the diaphragm.

In infants with congenital deficiency of a portion of the diaphragm attacks of cyanosis and dyspnea, followed by vomiting usually direct attention to the existing state of affairs. Hernia through the esophageal hiatus is not to be confused with a congenitally short esophagus in which the stomach may be in the thorax (Bailey).

Treatment

In intestinal obstruction due to diaphragmatic hernia of traumatic origin, ordinarily no direct attack should be made on the intestine incarcerated in the thoracic cavity until the obstructive element has been dealt with. The present high mortality of 67 deaths (53.1 per cent) among 126 cases of intestinal obstruction occurring in the 378 cases reported by Hedblom is indicative not only of the danger of incarceration of the intestine in the thoracic cavity but also of the fact that too much surgery has been undertaken. The strangulating mechanism being less rigid in diaphragmatic hernias than in most external hernias devascularization of the imprisoned loops does not occur as readily. In six cases of bowel obstruction due to diaphragmatic hernia in children True performed primary cecostomies and only secondarily reduced the hernia and repaired the defect in the diaphragm; there were no deaths in this series. The release of the intestines and closure of the rent in the diaphragm is to be performed through the abdomen though occasionally when the intestine is adherent to structures within the thoracic cage as not infrequently happens a thoracotomy will also have to be made to free the bowel and other structures from their abnormal attachments. A preliminary x-ray film will serve to indicate which portion of the bowel is obstructed. Distended small intestine may be decompressed by suction applied to an intubing duodenal tube; if the colon is obstructed cecostomy or colostomy is indicated. A preliminary section of the phrenic nerve as advised by Harrington will frequently diminish the tension of the muscle pull of the diaphragm upon the gut and improve the patient's status. In the experience of the writer the intubing duodenal tube accompanied by positioning of the patient to help empty the fundus of the stomach which lies frequently in the thorax helps more than any other single item in getting rid

of cyanosis and dyspnoea. It is important to take check up films, before operation, to see that the distended stomach has been decompressed satisfactorily.

In the congenital hernias, the most common defect is absence of the posterior one fourth of the diaphragm. In the one experience which the writer has had with the repair of this condition in the new born, the peritoneal cavity appeared to be too small to hold the bowel after closure of the diaphragmatic defect. The sutures in the peritoneum and fascia for closure of the vertical left rectus incision had to be removed in order to permit of replacement of the gut in the peritoneal cavity, interrupted sutures of linen placed in the skin alone being depended upon. The infant stood the procedure well, but died from a puncture pneumothorax of the lung several days later. At necropsy the left kidney was still in the thorax. Orr and Neff, in recording a successful case, state that 16 infants under one year of age have been submitted to operation for the repair of a diaphragmatic hernia. The mortality was 47 per cent.

Repair of a diaphragmatic hernia may be undertaken either through an abdominal or a thoracic incision, or through either with a separate complementary incision into the other cavity, or through continuation of an incision in either cavity into the other. In the main, the abdominal incision has the wider range of usefulness. The writer, has employed the long left subcostal incision in the repair of diaphragmatic hernia—the same incision which has proved so useful in gaining access to the fundus of the stomach in extensive or total gastric excision. The maneuver of Mayo, to inject air into the pleural cavity, to facilitate intraperitoneal replacement of the abdominal viscera, herniated into the thorax, is an excellent procedure (Fig. 119). If the peritoneal viscera are not adherent to the lung, thoracic wall or pericardium, employment of the Mayo maneuver or slitting the diaphragm will permit ready reduction. In traumatic hernias of long standing, in which intimate adherence of thoracic and peritoneal viscera is present, employment of the complementary thoracic opening may be necessary to effect complete and safe reduction of the hernia.

Weinberg (1937) has suggested employment of the loose mobile perirenal fascia in the closure of large diaphragmatic defects—a suggestion which this writer has found to be useful. The small pleuro peritoneal hiatus hernias may be closed satisfactorily with Halsted mattress sutures of silk. When feasible, imbrication by overlapping insures a completely satisfactory result. Silk is to be preferred to catgut for the closure.

B. INTESTINAL OBSTRUCTION DUE TO HERNIA INTO THE FORAMEN OF WINSLOW

Pathogenesis

Ullman in 1924, and Lewis and Miller in 1927 made comprehensive reports on this subject. Lewis and Miller found 34 cases reported in the literature up to that time.

The entire mobile small intestine and a large portion of the colon may find its way through the foramen of Winslow into the lesser peritoneal sac. The condition may occur at any age, the youngest having been 5

years and the oldest aged 77 The greater number of patients have been reported in the male sex An abnormally mobile mesentery appears to predispose to the condition The small intestine most frequently herniates into the foramen and, in less than one third of the cases, portions of the large intestine and usually the appendix, ascending and transverse colon have been found to be contents of the sac

Pathology

A large segment of the bowel may become imprisoned in the lesser omental bursa or only a short loop One instance is reported in which a diverticulum of the intestine was the only content of the sac and in two instances a portion of the jejunum was the only segment of gut strangulated In a few instances the sac has ruptured and the intestine has herniated into the transverse mesocolon or through the gastrohepatic omentum Bowel has entered the lesser omental bursa through an opening in the gastro colic omentum An associated intussusception from the ascending into the transverse colon has been found co incident with hernia of the intestine through the foramen of Winslow Langley reports an instance in which two types of internal hernia were present one was pericecal, the other through the foramen of Winslow The short jejunal loop in the foramen was non viable and the patient died The bowel within the lesser sac usually dilates moderately rapidly and has been found perforated A number of cases of strangulation in this type of hernia occur constriction of the bowel is occasioned by the structures bounding the aperture In front in the gastro hepatic omentum are the common bile duct, portal vein, and hepatic artery behind the inferior vena cava and the spinal column

Clinical Features

The condition has never been diagnosed pre operatively and has occasionally not even been recognized at operation The symptoms of intestinal obstruction apparently develop moderately slowly At any rate, Green who has studied this point in particular, finds that in a large number of cases considerable time has elapsed between the onset of the symptoms and the appearance of the findings demanding operation In several cases the pain has been moderately severe, there has been little or no vomiting—an observation attributed largely to the fact that after the content of the stomach and duodenum is evacuated compression of the small intestine precludes the return of more intestinal content by vomiting When the infarcted segment is long, the blood loss may be great

Treatment

The important feature in the management of these cases is early recognition that a serious lesion exists and early resort to operation The absence of a good deal of intestine from the free peritoneal space and the presence of a cyst-like mass in the upper right abdomen at operation should establish the diagnosis In some instances reduction by simple traction on the herniated bowel suffices to return the intestine to the free

of cyanosis and dyspnoea. It is important to take check up films, before operation, to see that the distended stomach has been decompressed satisfactorily.

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states that 40 verified instances of right paraduodenal hernia have been recorded. Together, therefore, there must now be upwards of 100 cases of so-called paraduodenal or mesentericoparietal hernias on record.

In the left paraduodenal hernia the inferior mesenteric vein runs in the free margin of the anterior covering of the sac and when operation is done for its relief this point must be remembered. The lower portion of

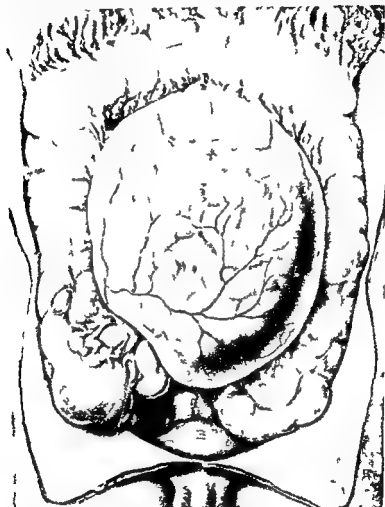


FIG 120.—Left paraduodenal hernia. (Desjardins Ann Surg 67 195 1918.)

the ileum is usually the first to become engaged in the sac the extraction of the more proximal loops should facilitate the reduction as Bramlett and A. H. Hurst have pointed out. The pocket points to the left and has its orifice at its right free margin. The fossa is usually known by the name of Landzert. It has on its right the root of the mesentery and posteriorly the peritoneum covering the psoas muscle, renal vessels, the ureter, and a portion of the left kidney.

peritoneal space In others, primary deflation of the obstructed intestine, preferably performed through an opening in the gastrohepatic omentum, should be done. Occasionally gentle stretching of the edges of the epiploic foramen will serve to permit reduction of the herniated content. Jean breaux and Riche describe a debridement of the foramen, an operation that they have developed on the cadaver to facilitate reduction of the intestine into the greater peritoneal sac. Through a short transverse incision in the gastrohepatic omentum just above the duodenum, the index finger of the left hand is insinuated through the omentum and the hepatic artery and portal vein pulled to the left. The right index finger then gently pulls the common duct to the right and gradually the foramen may be enlarged because of the laxity of the retroduodenal tissues. If the bowel is non-viable, it may be amputated and removed from the left side of the gastrohepatic omentum.

It is an interesting fact that in cases of recovery following reduction of strangulated hernia through the epiploic foramen, the time elapsed between the onset of symptoms and operation was nine days, in the series that died, the interval was only five days. It is therefore apparent that the degree of strangulation is the best index of the prognosis. About a dozen operative recoveries have been reported. Engstad stresses the importance of enterostomy as the most significant feature of a well planned operation in the ill patient. Recent successful reductions of bowel strangulated in the foramen of Winslow have been reported by Aigrot, Gabrielli and Mitchell.

C PARADUODENAL HERNIA

(Mc entericoparietal or retromesocolic hernia)

Pathogenesis

In his classical monograph on retroperitoneal hernia, Moynihan described nine different fossae in the neighborhood of the duodenum. Two of these occasionally entrap the intestine behind the mesentery and give rise to intestinal obstruction. Objection has been raised to the belief that the bowel finds its way into these preformed pockets. Andrews in a forceful paper insists that the term retroperitoneal hernia is a misnomer and believes that the small bowel is imprisoned behind the mesentery of the developing colon. Longacre, Haymond and Dragstedt, and a number of continental observers (quoted by Longacre) support this thesis. The condition is also said to have been present in the new-born, an item which speaks strongly against the pushing force of the bowel in enlarging the peritoneal pocket.

Pathology

These hernias may be divided into two fairly strict divisions—left and right duodenal hernia. In 1917 Desjardins stated that 85 cases of left paraduodenal hernia had been reported. In 1924, Nagel said that 100 such cases were on record. Occasionally these hernias are strangulated but a chronic type of obstruction appears to be more frequent. These patients frequently have an indefinite type of complaint for which they are treated by conservative measures over a number of years. Exner

- 1 In right paraduodenal hernia, the opening of the sac is on the left and the opening faces to the left
- 2 In left paraduodenal hernia, the opening of the sac is on the right and the opening faces to the right (see Fig 120)
- 3 The superior mesenteric artery runs in the anterior free margin of the sac in right paraduodenal hernia
- 4 The inferior mesenteric vein runs in the free margin of the anterior wall of the sac in left paraduodenal hernia

Treatment

The potential for obstruction is always present and when the condition is discovered accidentally, the sac should always be laid open and dealt with in such a manner that recurrence of incarceration will not be likely. The surgeon must always be mindful of the position of the blood vessels in the anterior margin of the sac. In speaking of right paraduodenal hernia, Exner states the history of the condition may be divided into three distinct periods "1861-1903 when 19 cases were described, but only 4 operations were performed and only one patient recovered, 1904-1923, when 10 cases were reported with 8 operations but still with only one recovery, 1923-1932, when 10 cases were reported and all were operated upon with 8 recoveries." The writer found most of the small intestine in a left paraduodenal hernial pocket recently at operation for duodenal ulcer. Repair of the hernia and gastric resection were carried out successfully at the same sitting. On a number of occasions a small paraduodenal hernial pocket has been found and closed at operation, incident to abdominal exploration.

D CONGENITAL HOLE IN THE MESENTERY

Hernia through a congenital aperture in the mesentery has as its favorite site, for strangulation of the intestine by this mechanism a persistent defect in the terminal mesentery of the ileum. Herniation of the intestine through a defect in either broad ligament has also been reported from time to time. Defects have been noted in the transverse mesocolon as well as in the gastrocolic omentum. Cutler has placed on record a case with recovery following intestinal resection after herniation of a portion of the intestine through an aperture in the mesentery. He refers to 28 other cases reported in the literature. Sohn related that about 53 cases of internal hernia through mesenteric defects were on record. Gatewood states that the disorder has not been identified prior to operation. In 1932 Edwards reviewed 20 cases, the mortality was 28.5 per cent. Martzloff found 15 recorded cases of prolapse of the bowel through a preformed opening in the greater omentum and added one more. Gentile observed another in 1933. Hunt and Masson and Atkinson have recently reviewed the instances of herniation through openings in the broad ligaments of the uterus. Fifteen such cases are to be found in the literature. Tears in the broad ligament after the Baldy Webster type of uterine suspension predispose to its occurrence. Loops of intestine may also become encircled

Right duodenal hernia is less frequent, Nagel having been able to find only 29 cases at the time of his report, 13 gave symptoms of acute intestinal obstruction. 6 had a history of previous similar attacks, 10 of the obstructed cases were operated upon, 8 of whom died with only two recoveries. The fossa of Waldeyer is the name of the pouch into which the intestine herniates itself. Nagel also states that hernia of this type may occasionally occur in the inferior duodenal fossa. The hernial sac of right paraduodenal hernia lies behind the ascending and transverse mesocolon. The small intestine is largely contained within this sac, whose orifice is situated behind and to the left of the sac on the lumbar vertebrae. The superior mesenteric artery or its continuation, the ileocolic lies in the anterior margin of the sac.

Clinical Features

Incarceration rather than acute strangulation characterize most of the obstructed cases. Stasis in the sac is usual even in those patients who have



FIG 121.—Right paraduodenal hernia. The coils of small intestine appear as though restrained in a bag.

few symptoms, an occurrence which aids in their recognition. The rounded, sharply circumscribed lower border of the barium mass in the bowel lends the impression that the small intestine is contained in a bag and serves to establish the diagnosis (Fig 121). A number of cases have been recognized by these findings alone (Kummer, Case and Upson, Taylor, Exner). It is problematic however, in an acutely obstructed case in which the oral administration of barium would be inadvisable, whether the gaseous distension of the imprisoned intestinal coils would give the same appearance. In unobstructed cases where the oral administration of barium is permissible roentgenologists have been able to decide whether the paraduodenal hernia present was of the right or left variety on the basis of (1) the relationship of the stomach and (2) the colon to the incarcerated mass of small bowel and (3) whether the terminal ileum lies outside the hernial sac (Exner). Non rotation of the small bowel is to be differentiated from paraduodenal hernia in that, there is no bag like arrangement of the intestinal coils and at operation, no sac is present. Peritoneal tuberculosis occasionally attends paraduodenal hernia—probably a result of the stasis. The writer observed this complication in a case of left paraduodenal hernia. At operation the surgeon may find the following criteria useful in the differentiation of right and left paraduodenal hernia (Averbach 1937).

pre operatively Reid has recently recorded another instance A 3 inch loop of jejunum 4 feet from the duodenojejunal angle had found its way into the intersigmoid fossa The patient died In addition to the successful case of Murphy, there are also operative recoveries reported after extraction and reduction of the incarcerated loop of small intestine by Krall and Erkes

F PERICECAL HERNIA

Three fossae may be recognized near the junction of ileum and caecum (1) ileocolic, (2) ileocecal (ileo appendicular) (3) retrocolic These anatomical pouches owe their origin to the formation of folds as related to the division of the ileocolic artery Only the two latter fossae are of surgical interest because of the possibility of arrest and strangulation of the intestine within the pocket

Moynihan found 7 authentic cases of ileocecal hernia on record Moynihan accepts as bona fide 6 cases of the retrocolic variety with intestinal strangulation of which two recovered One of these was operated upon by Körte and reported by Aschoff Van Hook reported the successful reduction of such a hernia in an infant 18 months old and more recently Pribram added another successful case in which 235 centimeters of small intestine were resected In 1935 Langley reviewed the literature upon the subject He states there are 26 cases of intestinal obstruction due to pericecal hernia reported Of this number 20 have been submitted to operation with 14 recoveries (30 per cent mortality), of the 6 not operated upon, all died

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about the loop that has been fixed to the abdominal wall in colostomy, unless care is taken to prevent such an occurrence by bringing the colon through the abdominal wall as far laterally as possible or by tacking the lateral parietal peritoneum to the loop employed for colostomy, in such a manner that complete encirclement is impossible.

Hernia of a loop of jejunum beneath the limbs of a gastrojejunal stoma has been observed after gastrojejunostomy as well as after gastric resection (Mayo and Magoun, and Armitage). Employment of a long afferent loop is believed to favor its occurrence.

The writer observed this complication once after subtotal gastric resection for duodenal ulcer. The patient returned with the clinical picture of obstruction five months after the operation, the patient having been completely well in the meanwhile. Because ingested barium failed to leave the stomach, a roentgen diagnosis of stomal obstruction was made. On the basis of palpable intestinal loops in the upper left abdomen and intestinal colic, the condition was diagnosed clinically correctly preoperatively. A loop of gut was found enormously distended. The loop could not be delivered. Employment of the tube suction device, shown in Fig. 47b, permitted complete emptying of the loop. It contained 750 cc. of a bilious greenish yellow fluid. The gas content of the loop was not measured. After the segment was emptied, it was observed to be the afferent loop to the gastrojejunal stoma which had herniated beneath the ascending and descending jejunal limbs of the stoma. The obstruction had been present for a week and the posterior aspect of the loop was agglutinated so firmly to the stomach and the posterior parietal peritoneum, to preclude freeing it. An enterovagotomy by the closed method was made. The patient has remained well and has continued achlorhydric despite the presence of the entero-anastomosis.

E. INTERSIGMOID HERNIA

The persistence of the sigmoid fossa is found in a fairly large number of bodies. In 100 cadavers examined by Treves such a fossa was found in 65 per cent of the cases. Moynihan has found it to be present in about 70 per cent of subjects. It is more constantly recognized in children and tends to become obliterated later in life. It is found on the left side of the mesosigmoid near its base. Its orifice is round and the pouch is funnel shaped and looks downward and to the left. It frequently contains the sigmoid vessels, behind which is the parietal peritoneum covering the left common iliac artery. Its developmental origin is due to zygois or physiological adhesion of the mesocolon to the posterior parietal peritoneum. Hernia into this fossa is a rare event. Copenhaver found no instance of its occurrence in the records of the Mayo Clinic. In a report made in 1924 by Bruce and Ross, the authors state that only 10 cases of intersigmoid hernia are to be found in the literature, one of these occurred in a new born, the oldest in a patient aged 66. All of these except one occurred in males. A successful case is referred to by the late J. B. Murphy where actual strangulation of the intestine necessitating excision of the herniated loop was necessary. The condition has not been correctly recognized

pre operatively. Reid has recently recorded another instance. A 5 inch loop of jejunum, 4 feet from the duodenojejunal angle had found its way into the intersigmoid fossa. The patient died. In addition to the successful case of Murphy, there are also operative recoveries reported after extraction and reduction of the incarcerated loop of small intestine by Krall and Erkes.

F PERICECAL HERNIA

Three fossae may be recognized near the junction of ileum and caecum (1) ileocolic, (2) ileocecal (ileo appendicular) (3) retrocolic. These anatomical pouches owe their origin to the formation of folds related to the division of the ileocolic artery. Only the two latter fossae are of surgical interest because of the possibility of arrest and strangulation of the intestine within the pocket.

Moynihan found 7 authentic cases of ileocecal hernia on record. Moynihan accepts as bona fide 6 cases of the retrocolic variety with intestinal strangulation of which two recovered. One of these was operated upon by Korte and reported by Aschoff. Van Hook reported the successful reduction of such a hernia in an infant 18 months old and more recently Pribram added another successful case in which 235 centimeters of small intestine were resected. In 1935 Langley reviewed the literature upon the subject. He states there are 26 cases of intestinal obstruction due to pericecal hernia reported. Of this number, 20 have been submitted to operation with 14 recoveries (30 per cent mortality) of the 6 not operated upon all died.

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CHAPTER XX

VOLVULUS

A PATHOGENESIS

Volvulus is most commonly observed in the following portions of the intestinal canal the sigmoid flexure of the colon, the cecum, and the small intestine. A long flexure in which the limbs of the loop are closely approximated, as in the sigmoid flexure, predisposes to the occurrence of volvulus (Fig 122). It is also a significant circumstance that in most instances in which volvulus of the sigmoid flexure obtains that an unusually large bowel or pseudomegacolon is often present. The frequent occurrence of volvulus in Hirschsprung's disease is well known, Weeks has reported several such occurrences.

The rarity with which volvulus of the transverse colon is seen bespeaks the importance in the development of torsion of a narrow attachment of the mesentery. The transverse colon despite its extreme range of motion escapes frequent twisting because its points of fixation at the hepatic and splenic flexures are so far removed from one another yet even torsion of the transverse colon has been reported (Braun and Wortmann, Melchior). Kallio has recently collected 16 cases of volvulus of the transverse colon.

In most statistical studies of intestinal obstruction volvulus constitutes about 10 per cent of the total number. In 1000 cases of intestinal obstruction Gibson reported 121 instances of volvulus. In Kuttner's Clinic at Breslau, 42 instances of volvulus were observed in 456 cases of intestinal obstruction. In Russia, Serbia, Finland, and Sweden, volvulus appears far more frequently. Out of 215 cases of intestinal ob-

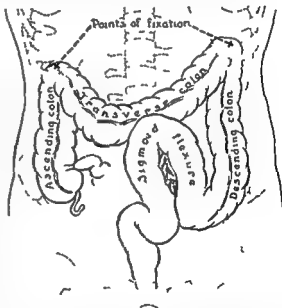


FIG 122.—The potential for volvulus in the colon. Sketch illustrating the ease with which volvulus may occur in the sigmoid flexure with a narrow mesentery; the lateral points of fixation of the transverse colon preclude frequent torsion of this segment of the bowel yet it does occur even here.

struction reported by Perlmann from a Russian surgical clinic, 111 or more than one half were cases of volvulus. Obalinski reports amongst 110 cases of intestinal obstruction, 38 instances of volvulus of which 19 occurred in the small intestine with concomitant rotation of the cecum in four of these, the other 19 concerned the sigmoid flexure. Spassokukozki reports 47 cases of volvulus in 96 cases of intestinal obstruction. Braun and Wortmann have grouped the reports of a number of Serbian authors. In 373 instances of intestinal obstruction, volvulus was observed 127 times.

In 53 cases of volvulus occurring among 520 cases of obstruction observed at the Massachusetts General Hospital, Sweet reports the following incidence of the various types of volvulus: 36 were observed in the small intestine, 67.9 per cent, 10, or 18.8 per cent, occurred in the sigmoid flexure, and the remaining 6 concerned the cecum, 11.3 per cent. Jacobsen found volvulus of the cecum and torsion of the small intestine to be most frequent among a group of cases of volvulus seen at the Viborg Hospital in Denmark. In 102 cases seen at the Friedrichshain Hospital, Braun and Wortmann list the following occurrence: Small bowel, 56 cases, sigmoid flexure, 31 cases, cecum 7 cases, small bowel and cecum, 4 cases, simultaneous torsion of cecum, ascending colon and transverse colon, 2 cases, and one instance of isolated torsion of the transverse colon and another of the stomach.



FIG 123—Volvulus of the sigmoid flexure necropsy specimen (Christopher's Textbook of Surgery, W. B. Saunders Co. 1936, p. 1220. Courtesy, Dr. V. F. Lukin.)

Small bowel, 56 cases, sigmoid flexure, 31 cases, cecum 7 cases, small bowel and cecum, 4 cases, simultaneous torsion of cecum, ascending colon and transverse colon, 2 cases, and one instance of isolated torsion of the transverse colon and another of the stomach.

Sigmoid Flexure

All writers stress the greater length of the intestine and the significance of vegetable diet amongst Russian and Serbian people as contributing factors to the frequent occurrence of volvulus of the sigmoid flexure. Curschmann found abnormally long flexures of the sigmoid in only 4.2 per cent of postmortems made in Germany, whereas Samson, in similar material in Russia, found unusually long sigmoid flexures in 20 per cent. Brehm observed these abnormally long sigmoid flexures to be more common in males than females, while Laurell states that they are equally as frequent in women as men. In necropsy material, Wessel (quoted by Fernstrom) found sigmoid flexures reaching above the umbilicus in 38 per cent of men and 48 per cent of women (68 autopsies). Fernstrom states that torsion of the sigmoid flexure occurs four times more frequently in males.

Strong muscular men more frequently than others fall victims to the disease. Laurell believes that the lesser capacity of the abdominal wall renders the occurrence of spontaneous reposition of volvulus less com-

mon in men than in women. The wider pelvis of the female and the relaxed abdominal walls occasioned by frequent pregnancies permit of greater room in the abdomen and probably of a better chance of spontaneous reduction, but at the same time these conditions would appear to encourage freer movement and a greater liability to the development of torsion.

The greatest incidence of volvulus of the sigmoid flexure occurs in mid

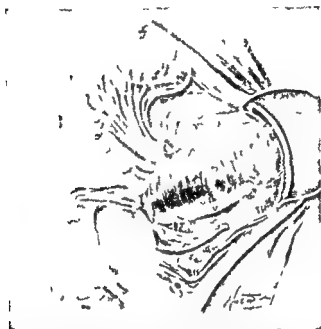


FIG. 121.—Volvulus of cecum. Owing to lack of mesenteric fixation of cecum repeated attacks of obstruction occurred. There was a 360° clockwise twist in the cecum about at the point of entry of the ileum which is moderately dilated.

dle and advanced years. In 119 such cases collected from the literature, Giffhorn observed the following age distribution:

TABLE XXXIX	
AGE INCIDENCE OF VOLVULUS OF THE SIGMOID FLEXURE	
10-30 years—	14 cases
31-50 years—	46 cases
51-70 years—	40 cases
71-90 years—	8 cases

Cecum

Lecène comments upon the rarity of volvulus of the right colon and in 1910 says that he could find but four other cases reported from all of France. Tait in Finland reported 28 cases in the five year period between

1897-1902 Faltin gave as explanation for this extraordinary frequency the large vegetable diet (especially potatoes) eaten there. Volvulus of the cecum is only possible in the absence of fixation of the cecum or in the presence of a mesocecum and mesocolon sufficiently mobile to permit of torsion (Fig 124). In such cases the cecum usually exhibits a continuation of the mesentery possessed by the terminal ileum. Many cases present in addition, failure of complete rotation of the right colon (Rixford).

Harvey noted unnatural free motion of the cecum and ascending colon in 13.3 per cent of examinations performed upon 105 infants at necropsy. Chalfant stated that unusual mobility of the cecum and ascending colon were present in about 20 per cent of persons of all ages.

Small Intestine

Volvulus of the small intestine owes its origin to defective fixation of the mesentery, there being frequently but a small pedicle from which

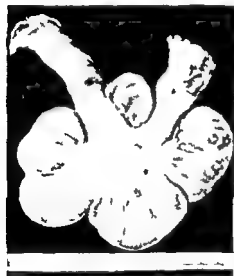


FIG 125—Enterocystoma of jejunum causing volvulus. Detorsion and primary closed resection were done.

the small intestine derives its blood supply. The process of rotation of the bowel and mesenteric fixation is described in another chapter (p. 421). Volvulus in the absence of mesenteric fixation has occurred in newborns and Dott has described this occurrence as *volvulus neonatorum*. When the small intestine and cecum have a common mesentery, a portion of the right bowel usually participates in the torsion. Volvulus of shorter segments of the small intestine may be occasioned by the presence of narrow adhesive bands. Wilms and Kallio have lent this type of intestinal strangulation considerable prominence under the caption of "knotting" of the intestine. Abnormal mesenteric bands are occasionally present in incomplete intestinal rotation and defective

mesenteric fixation. Tumors of the small intestine may initiate torsion and volvulus of the bowel (see Fig. 125).

Stomach

Volvulus of the stomach occurs in the distended hypermobile stomach. Overfilling and gaseous distension are frequently contributory factors. Torsion of the stomach occurs occasionally in diaphragmatic hernias, in the presence of tumors in the stomach, inflammatory processes in the vicinity of the stomach, and in the presence of displacements of other contiguous viscera (Payr).

B PATHOLOGY

Torsions of 180° to 360° are usual, but in cecal torsion and volvulus of the small intestine, twists of 520° to 720° may be seen. With broad mesenteric attachments, a twist of more than 180° is unusual. The tightness of the twist rather than the number of turns determines whether the pathologic changes of tissue necrosis will follow. Mesenteric cysts occasionally give rise to torsion of the intestine and volvulus of a portion of the small intestine may occur when a gallstone blocks its lumen. The nature of the content of the torsioned loop is subject to considerable variation. In incomplete obstructions or those in which the torsion develops gradually, both gas and fluid may be found in quantities within the strangulated segment, in consonance with the experimental observation that a loop of gut cut off from the oral source of swallowed air or a closed loop will have little gas in it. Similarly, when complete occlusion of the bowel is established by torsion, the fluid within the loop will usually exceed the gas present. Free peritoneal fluid, hemorrhage into the bowel, and infarction of its wall, gangrene, and perforation of the twisted segment with associated peritonitis are natural sequelae of the occurrence. In volvulus of the sigmoid, developing commonly more insidiously than cecal and small intestinal torsion, dilatation of the proximal segment is also frequently present.

The direction of the twist in torsion of the small intestine is usually clockwise though counter clockwise twists are observed. Similarly, torsion of the cecum is usually clockwise but Faltin, in 47 cases found 27 to be clockwise and 20 counter clockwise. Both varieties occur also in the sigmoid, but the clockwise twist is the more frequent.

C CLINICAL FEATURES

Sigmoid Flexure

In volvulus of the pelvic colon, abdominal distension usually dominates the picture. The strangulated loop frequently stands out prominently and occasionally, can be outlined as an elastic mass beneath the abdominal wall. This stiffening of the bowel, frequently described as Wahl's sign, is significant of the presence of an infarcted gut in which hemorrhagic infarction due to venous occlusion occurs in consequence of the torsion. With volvulus developing more slowly, enormous gaseous distension of the twisted loop is more likely to be made out on percussion or noted on a skiagram. In torsion of the pelvic colon, antecedent lesser attacks of pain and a story of obturate constipation are not infrequent. Tenesmus and bloody mucus in the rectum are not infrequent. The signs of a mechanical obstruction, viz., severe crampy pain, nausea, and vomiting and intestinal borborygmi are invariably present. *Intestinal colic* and a tender abdomen indicate that a strangulating obstruction is present. When the loss of blood into the infarcted segment is great, shock is usually in evidence.

Fernstrom recognized three types of volvulus in the pelvic colon: (1) the acute type, (2) acute recurrent attacks of short duration, and (3)

the chronic atypical, with slight or moderate pain. Patients with a long pelvic flexure, who are subject to constipation and periodic attacks of pain relieved by an enema, in which a barium study reveals no intrinsic lesion in the bowel, may fall into Fernstrom's third type of atypical chronic volvulus. He states that he had administered barium enemas



FIG 126—Configuration of the sigmoid flexure in recurrent volvulus in a patient complaining of frequent attacks of abdominal pain associated with meteorism; the potential for volvulus is apparent.

during such attacks of pain and has found the opaque mixture to stop abruptly at the beginning of the pelvic colon. Subsequent progress of the barium into the pelvic loop frequently stops the pain. Larimore states that patients with this type of disorder frequently have an achlorhydria. The potential for the occurrence of torsion is apparent in the accompanying film of a patient who was subject to frequent attacks of abdominal pain such as that described above (Fig 126).

Determination of the capacity of the colon, by permitting as much water to run in under the force of gravity as the patient will tolerate, is frequently mentioned as a sign of diagnostic import in volvulus of the sigmoid flexure. Ordinarily, three to four liters of water can be introduced into the unobstructed colon of the adult without difficulty and occasionally as much as six, inability to introduce 500 cubic centimeters of water has been consid-

ered of diagnostic importance for volvulus. X-ray evidence of gaseous distension as observed on the scout film of the abdomen or the barium enema would give more reliable information.

Volvulus of the Small Intestine and Cecum

The symptoms of these two disorders, in the main, are quite similar. As related above, their occurrence is predicated on the same etiologic agent, viz., inadequate mesenteric fixation. The obstruction of the small intestine in this type of volvulus gives rise usually to copious and frequent vomiting. In a twist involving the entire small intestine, distension may concern only the stomach and duodenum, the occluded and strangulated segment being essentially gas-free. Incomplete occlusion, however, may give rise to enormous gaseous distension. Codman refers to a patient with volvulus of the small intestine in which the distension was considerable but the patient after vomiting initially failed to bring up any more content from the stomach. This observation he feels should suggest the pos-

sibility of torsion of the small intestine. In the main, the symptoms are more acute in volvulus of the cecum or small intestine than in torsion of the pelvic colon. Yet, chronic types of these varieties of volvulus have also been described (Poynton, Liebe, Baumlér).

II DIFFERENTIAL DIAGNOSIS

Mesenteric thrombosis, acute pancreatitis, peritonitis, and strangulation of an internal hernia from some other cause, may mimic torsion of the bowel very closely. Pre-operative differentiation is less important than recognition of the fact that tenderness, peritoneal irritation, moderate rigidity, and distension point unequivocally to the presence of a surgical lesion. The presence of *intestinal colic* in volvulus helps to exclude non-obstructive disorders. Dott believes that the following will serve to identify volvulus of the small intestine: (1) The signs of bowel obstruction accompanied by the vomiting of bile. (2) Distension of the upper abdomen from dilatation of the stomach and duodenum with a flat lower abdomen. (3) Presence of blood stained mucus in the rectum.

In the infant or new born, presenting symptoms and signs of intestinal obstruction, volvulus of the small intestine is to be considered as a likely possibility. For apart from congenital intestinal atresia, it is the only frequent cause of intestinal obstruction in the new born and young infant. Ladd has pointed out that atresia is likely to be accompanied by considerable vomiting from the start, whereas, in volvulus vomiting and symptoms of obstruction are more likely to occur after the lapse of some weeks after birth. Failure of rotation of the bowel in which condition the small intestine lies on the right side of the abdomen, and the colon on the left, is a common cause of volvulus of the small bowel. The occurrence of abdominal pain and distension in a patient having this condition should conjure up in the examiner's mind the possibility of volvulus of the small intestine. The presence of a mass, in the mid abdomen accompanied by signs of intestinal obstruction attended by tenderness, should suggest the possibility of volvulus. My associate Dr Clarence Dennis, made the diagnosis in a recent case, on this basis (see Fig 125).

From volvulus of the sigmoid flexure producing obstructive rather than strangulating symptoms, colitis has to be differentiated. Discharge of bloody mucus from the rectum is occasionally observed in volvulus but the signs of mechanical obstruction to the continuity of the intestine dominates the picture, whereas, in colitis, these are either totally absent or remain well in the background. Stenosing carcinoma of the sigmoid must be considered in the differential diagnosis of torsion of the sigmoid flexure. Endoscopic examination of the bowel, a barium enema, and the absence of strangulating phenomena in carcinoma help to establish a preoperative diagnosis. In carcinoma of the sigmoid colon causing obstruction tenderness if present is more likely to occur over the cecum because of its distensibility. Volvulus concomitant with carcinomatous obstruction at the flexure does occur.

III TREATMENT

The treatment indicated for torsion of the intestine is early operation and liberation of the strangulated segment. When the operation is done soon after the symptoms appear, simple untwisting of the strangulated segment is all that is necessary. Evisceration of the strangulated loop through an adequate incision facilitates detorsion. Puncture and aspiration of the contents of the twisted loop may have to be done as a preliminary measure. The presence of considerable distension calls for drain

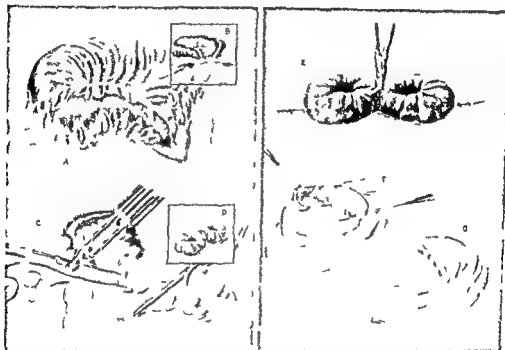


FIG 127—The exteriorization operation (Bloch Paul Mikulicz) for volvulus of the colon. A The exteriorized bowel after detorsion. Occasionally the bowel has to be aspirated in the manner shown in Fig 47B to permit detorsion. B Approximation of the adjacent limbs of the bowel. C The exteriorized devitalized bowel is amputated on completion of the operation. Note the presence of a catheter in the proximal limb of the colon to obviate tension in the bowel. D The resultant external stomas after the small crushing Payr clamps drop off (usually about the 8th postoperative day). E The spur is crushed before the patient leaves the hospital. It takes about 7 or 8 days for the large Ochsner forceps to cut through. F and G Closure of the colostomy.

age of the bowel. Where the vascular occlusion has been of severe degree and has existed for some length of time, circulatory changes in the intestine necessitate the performance of a more formidable procedure. When the intestine fails to show signs of viability, excision or exteriorization must be performed.

In torsion of the sigmoid flexure that has progressed to devitalization, exteriorization by the Bloch Mikulicz technique is the operation of choice with immediate opening of the bowel upon completion of the operation. If the bowel is of questionable viability, exteriorization with proximal

colostomy would appear to be the best operation. In cecal volvulus, detorsion and exteriorization of the damaged cecum and cecostomy may be considered the operative procedure of choice in instances in which the bowel is non viable. Yet primary resection with immediate closed anastomosis, if the distension is not too forbidding, is probably an even better operation. In volvulus of the small intestine, if after detorsion the bowel is found to be non viable, a primary resection and anastomosis is to be preferred to exteriorization in those instances in which the greater part of the small intestine is concerned. Doersler's very extensive primary resection of the bowel referred to on page 456 was performed for volvulus of the small intestine. I add has well described the manner of performing detorsion for volvulus of the small intestine in infants and children.

It is well known that following detorsion, a number of instances of volvulus of the sigmoid flexure re occur. Finsterer reports 13 recurrences amongst 47 cases of volvulus of the sigmoid flexure when detorsion only was done. Obalinski, von Eiselsberg and Philippowicz have all seen recurrences of volvulus of the sigmoid flexure after detorsion and stress the necessity for more radical therapy. Bloodgood reports two such cases, one had been operated upon in his first attack at which time the torsion was reduced. This patient had 32 attacks during the following 16 years. After the thirty second seizure, Bloodgood excised a portion of the sigmoid and made a lateral anastomosis with complete relief for the patient.

Makins reports an instance of idiopathic dilatation of the sigmoid flexure upon whom six operations were performed. The whole repertory of surgical procedures had been practiced with the single exception of colostomy. Colopexy, plication and lateral anastomosis had all been made without effect. certainly the performance of entero anastomosis between two distended segments of such a loop is not to be recommended. Colopexy, and plication of the mesentery as well as of the bowel itself seem to be uncertain methods in the treatment of the condition. Exteriorization with excision of the greater portion of the loop concerned or primary resection by the closed method is the method of choice in recurrent cases. The potential for recurrence of volvulus of the cecum or small intestine also obtains unless more adequate fixation of the wall of the cecum or of the mesentery of the small intestine is provided.

F MORTALITY

The mortality of operations for volvulus has been unusually high, but has its explanation in the fact that most cases come to operation late. Philippowicz reports 43 cases of volvulus of the small intestine. patients presented themselves for operation on the average on the fifth day of their complaint. In the 36 cases in which torsion of the root of the mesentery occurred 13 recovered (36 per cent) two however were too ill to be submitted to operation. Bundschuh has collected 110 cases of cecal volvulus from the literature, 23 died without operation. Of the 87 submitted to operation, 52 cases (60 per cent) died.

For torsion of the sigmoid flexure the results are somewhat better the syndrome being more easily recognized and strangulating effects occurring

less frequently Perthes reports a 39 per cent mortality. Of the 39 cases of volvulus of the sigmoid submitted to operation reported from the Russian surgical clinic of Rubaschew by Perlmann, there were 18 deaths (46 per cent mortality). In the cases in which gangrene was present necessitating excision, the mortality was 80 per cent. Muschkatin has recently reported seven cases of torsion of the pelvic colon all of which, but one, recovered after operation. He exteriorizes the strangulated loop and anchors the viable ascending and descending limbs of the colon in the wound. The devitalized portion is excised and a primary end-to-end anastomosis is made. The mesentery from the strangulated loop is saved and is sutured over the anastomosis, which is then left beneath the skin because of the risk of fistula formation. He believes that this method is to be preferred to a two stage resection by the Bloch Mikulicz method (Fig 127). Koster (1940) has advocated, recently, extraperitoneal placement of the anastomosis, after colonic resection for malignancy. Whereas, such a procedure may have some justification, when primary anastomosis is performed for colonic obstruction, it would appear that extraperitoneal placement of the anastomosis in unobstructed cases suggests that the surgeon has little confidence in his capacity to make a satisfactory anastomosis.

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CHAPTER XXI

INTUSSUSCEPTION

A FREQUENCY

THE incidence of the occurrence of intussusception in the various quarters of the world varies considerably. Souttar (London) states that 20 per cent of all cases of intestinal obstruction are cases of intussusception. Invagination constitutes a fairly large proportion of all cases of intestinal obstruction in England, Denmark, and Australia, however, it appears to be definitely less frequent in the United States and Germany.

About 75 per cent of all instances of the disease are seen in children under two years of age—more than one-half of the cases occurring in the first year of life, and most of these are observed between the fourth and ninth months of life. The remaining 25 per cent divide themselves throughout the years, being more frequent in early childhood than in later years.

Among 400 cases seen over a period of 18 years from 1903 to 1920 inclusive at the London Hospital, Perrin and Lindsay found 314 cases (78.5 per cent) in the first two years of life, 279 cases (69.75 per cent) were under one year of age. There were only 18 cases more than 14 years of age in this series. Of the 400 cases, 203, or slightly over 50 per cent, occurred between the ages of five and nine months. Two hundred seventy-two cases (68 per cent) were males and 128 cases (32 per cent) were females.

The disease usually affects healthy infants. An abuse of cathartics is said to be causative, but Monrad says that, in Denmark this explanation can not be said to account for the high incidence of the disease observed. Whereas in adults a tumor or a Meckel's diverticulum is often present as the etiologic factor in the genesis of the intussusception, almost invariably in infants no apparent cause is found. Enlargement of Peyer's patches of lymphoid tissue in the terminal ileum has been ascribed as a frequent cause of invagination by many authors, particularly Walton, Hipsley, and Clubbe. Walton states that the lymphoid tissue forms a ring about the ileocecal valve corresponding to the sacculus rotundus of lower animals. Though this is the segment of intestine usually involved in intussusception, the greater frequency of the disease in males can scarcely be accounted for on this basis. Lymphoid tissue elsewhere in the body reaches its greatest growth at about eleven years (Bovd), and it would be logical to assume that if Peyer's patches of lymphoid tissue followed the same growth curve there would be a large number of cases of invagination occurring in the early teens.

Matti has suggested that the frequent occurrence of the ileocecal type of intussusception is due to the fact that vigorous peristalsis is countered by antiperistalsis in the cecum. A large portion of the cases occur at the

time of weaning from the breast and it is believed that this change in the dietary regime may occasion spasm in the bowel

Nothnagel produced intussusception by stimulating the intestine with a direct Faradic current, Propping produced similar small invaginations in rabbits by administration of physostigmine To all experimental workers in the field of intestinal obstruction, the occurrence of intussusception following severance and inversion of the ends of the upper small intestine is well known Failure to attach the distal segment to a fixed point, such as the abdominal wall in the dog, is frequently followed by invagination of the distal free end and its mesentery distally into the small intestine

My associate Dr Clarence Dennis, obtained three skunks to study the secretory capacity of the cecal appendage Two died of jejunal intussusception before surgical exploration was carried out apparently due to dietary changes The third skunk died of intussusception after exploration The skunk like the bear and the raccoon, has no cecal appendage or homologue of the vermiform appendix of man The small intestine and colon meet without the anatomical landmark of an ileocecal valve and sphincter

In cases of intussusception observed after the age period during which the occurrence of the disease is frequent, tumors are frequently found as causative factors in the development of the invagination Polyps leiomyomas lipomas, fibromas polypoidosis of the intestine and carcinomas are commonly offending agents and occasionally a cyst or solid tumor of the mesentery near the bowel wall may initiate the invagination Of 45 cases of fibroma of the intestine collected by Clifton and Landry, 33 caused intussusception Amongst 326 cases collected by Wellington in which a Meckel's diverticulum gave origin to acute trouble necessitating surgical intervention, bowel obstruction was present in 144 instances, of which number 59 were cases of intussusception When intussusception occurs in late childhood or later the presence of a tumor or Meckel's diverticulum is to be suspected Such tumors may occasionally cause intussusception in nurslings

Eliot and Corcoran analyzed 300 cases of intussusception in adults, a tumor was found in the bowel in 40 per cent of the cases of which 24 per cent were benign and 16 per cent were malignant Ulceration in the bowel of tuberculous bacillary or typhoid origin accounted for 14 per cent of the cases of intussusception In 12 per cent a Meckel's diverticulum was present and, in a few instances, the intussusception appeared to have been initiated by trauma Kasemeyer records 284 cases of tumor invagination of which 208 were due to tumors and the remaining 76 to Meckel's diverticulum and other causes Of the neoplasms causing intussusception, 38 per cent were malignant In the remainder of the group, the cause of the intussusception was not apparent

Chaffin Mason, and Slemons have recently collected from the literature 20 cases of intussusception associated with pregnancy The writer has once noted this occurrence It concerned a short enteric intussusception during the sixth month of gestation

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through the ileocecal valve and the pure enteric are small intestine invaginations. A rare type of invagination, of which Huddy has collected 68 examples, is intussusception of the appendix in whole or in part into the cecum in the manner of inversion of the finger of a glove. They occur more frequently in childhood than in later ages. Christopher (1938) reports a recent successful case and states that 80 cases are to be found in the literature. In the Italian literature there have been reports of invagination of the haustra of the cecum (Girard and Savona 1910). Some of these the writers say, have gone on to gangrene.

Other atypical intussusceptions are to be mentioned such as the invagination of one or both loops of the jejunum through a gastrojejunostomy stoma into the stomach. Chamberlin (1940) reports successful reduction of a recurrent jejuno-gastric intussusception through a gastrojejunostomy stoma.

Reports of more than 40 such cases are to be found in the literature. In a patient for whom the writer did a gastrojejunostomy in 1925 for chronic duodenal ulcer and excision of a segment of small intestine just beyond the duodeno-jejunal flexure in 1929 for a chronic bowel obstruction occasioned by collection of intestinal content in a number of diverticula on the mesenteric border of the bowel this accident happened one month fol-

lowing dismissal from the hospital after the last operation. The diagnosis was made by Dr Rigler, roentgenologist to the University Hospital and is well supported by the accompanying film (Fig 129). The patient refused operation and subsequent examinations made showed spontaneous reduction to have occurred. The operative mortality in early reductions is said to be about 10 per cent (Bettmann and Baldwin). A few instances of intussusception of the stomach into a dilated duodenum have been observed in the presence of a tumor in the stomach (Henchen). Gastric polyps on a pedicle in the antral area of the stomach may protrude into the duodenum and obstruct periodically or initiate obstruction by bringing intussusception about.

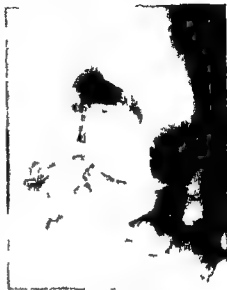


FIG 129.—Retrograde intussusception of jejunum through gastrojejunostomy stoma. The filling defect in the stomach indicates the jejunum. The patient refused operation and the invagination was reduced spontaneously.

C TYPES OF INTUSSUSCEPTION

Though some indication may be present the exact anatomical variety can only be determined with accuracy at operation on reduction of the

Spastic obstruction occasionally is the initial forerunner of invagination of the bowel. Intestinal worms, especially the *Ascaris*, have been known to cause intussusception (See obturation obstruction chap 14.) Rost was able to isolate from worms a substance that produced vigorous peristalsis in the intestine of the cat.

In South Africa, where infestation of sheep with the larvae of *Oesophag*

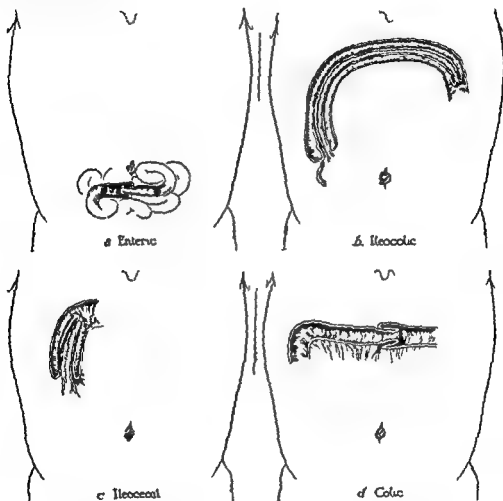


FIG 128.—The various types of intussusception (Radiology 17 41 1931)

ostoma in the intestinal wall is common sheep are commonly affected with intussusception (Marek)

B PATHOLOGY

Cases of intussusception may be divided into two main groups, viz, large and small intestinal invagination each again divided into two subgroups. The ileocecal in which the caput ceci forms the apex of the invaginated bowel and the pure colic, constitute the intussusceptions of the large intestine. The ileocolic in which the lower ileum prolapses

whether such transient intussusceptions form occasionally and reduce themselves in the postoperative period

Agonal intussusceptions are usually of the ascending variety. They are very short and are frequently multiple. They exhibit no inflammatory reaction in the bowel wall and are easily reduced. They are probably caused by tumultuous contraction of the bowel in response to asphyxia of the tissue.

D MANNER OF GROWTH

"The growth of an intussusception occurs exclusively at the neck. The apex of the intussusception soon becomes edematous, stiff, and swollen, and once this has happened it is impossible for the apex to change. The driving force is supplied entirely by the ensheathing layer or intussusciens. As in normal peristalsis, the circular fibers of the sheath contract strongly above, driving the intussusception on and forming a fixed point from which the longitudinal fibers can act. These act in one of two ways. If the sheath is loose, they pull it over the intussusception like a sleeve. If it is tight, they drive the intussusception into it. This is the only way in which an intussusception can grow" (Souttar).

It might appear that the drag of the mesentery between the entering and returning layers would limit progression of the invagination. The mesentery, however, is attached about the center of a horseshoe, formed by the large intestine, and from this center the mesentery swings round like the hand of a clock modifying the elongation required. In infants, the peritoneal attachments of cecum and ascending colon are incomplete permitting of greater displacement. The great mobility of the colon in infants may allow of the protrusion of the ileocecal valve through the anus where it may be identified by the orifice of the appendix. Bonomini (1938) states that, the longer mesentery permits a greater length of invagination. A thick short mesentery on the contrary offers less opportunity for the development of a long intussusception. Bonomini observes also that the nearer the entrance of the intussusception to the root of the mesentery, the greater is the opportunity for a greater length of invagination.

E PATHOLOGICAL CHANGES

The obstruction in intussusception is afforded by the active contraction of the sheath and especially at its neck. An actual block of the lumen does not exist. The continuity of intestinal lumen between oral and distal segments remains intact and in chronic intussusceptions in which the bowel wall changes are not as marked, the intestinal current is preserved.

The greatest alteration in the bowel in acute intussusception occurs in the intussusceptum. The walls of the invaginated segment become rapidly edematous, stiff and engorged with blood and extravasation of blood into the lumen occurs. The mucus appearing in the stool has its source in the activity of the mucous glands in the strangulated intussusceptum. Acute intussusceptions tend rapidly to become irreducible.

invagination In the ileocolic variety, the vermiform appendix and a portion of the cecum remain external to the invagination in contrast to their internal situation in the ileocecal type When the ileocolic variety is completely unfurled, it is apparent that some of these are double or compound, i.e., a pure enteric type of invagination started at a short distance from the cecum, rarely more than six inches away and this intussusception has become invaginated into the cecum or ascending colon

Whereas, the usual intussusception consists of three cylinders, viz., internal and returning layers, constituting the intussusceptum and the outer tube known as the intussusciens, a double intussusception presents five cylinders and as many as seven may be present in a compound intussusception

TABLE XL—INCIDENCE OF THE VARIOUS TYPES OF INTUSSUSCEPTION

	Fitzwilliams	Perrin and Lindsay	Clubbe
Year	1903	1921	1921
Total number of cases	648	330	253
Variety of intussusception	Per cent	Per cent	Per cent
Ileocecal	60.8	46.5	57.6
Ileocolic	25.6*	37.6	31.8
Enteric		10.1	8.8
Colic	7.3	5.6	2.0
Multiple and double	6.1	—	—

* Includes also enteric intussusception

Agreement is not absolute amongst all observers as to which is the most common type of intussusception By far the majority of instances of intussusceptions in children occur about the ileocecal region A few contend that the ileocolic variety is most frequently found, whereas in practically every large series, ileocecal invaginations are the most numerous as table 40 attests

Intussusception is almost invariably of the descending variety, a portion of the intestine being invaginated into a more distal segment Kausch observed an instance of ascending invagination of the intestine in 1921 and collected 41 similar instances from the literature Groper (1940) reported a recent successful reduction of an ascending intussusception and reviewed the literature on the subject D Arcy Power has observed a descending and an ascending intussusception in the same individual Buckley reports superimposition of a retrograde upon a descending intussusception Just before closing the abdomen after a tedious and difficult gastric resection, the writer has twice observed an enteric intussusception which had developed during the course of the operation In one instance, the tumor was hard and was not reduced easily There was no obvious cause of the invaginations and both patients recovered One wonders, naturally,

whether such transient intussusceptions form occasionally and reduce themselves in the postoperative period

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owing to the changes in the intussusception. Ulceration, gangrene and perforation of the invaginated bowel may occur in irreducible intussusceptions. The intussusciptiens rarely shows significant gross changes. It is not infrequently congested and may exhibit deposits of fibrin or other evidence of local peritonitis. Occasionally it may even perforate consequent upon the pressure of the invaginated bowel upon it. In chronic intussusceptions, the encsheathing cylinder is often thickened. The bowel above the obstruction is usually dilated somewhat and presents evidence of congestion. In chronic invaginations the proximal bowel may undergo considerable hypertrophy.

F CLINICAL FEATURES

There are four cardinal symptoms of intussusception: (1) periodic attacks of pain, (2) vomiting, (3) passage of mucus and blood by rectum, and (4) presence of a palpable tumor in the abdomen.

Pain

Pain and vomiting are practically constant in occurrence. The sudden onset of painful seizures in a previously healthy baby is a peculiarity of intussusception. After a little, the infant seemingly recovers and regains its cheerfulness and carries on as usual, if old enough it resumes play. In a little while the infant cries as if in pain, and then alternating pain and relief occur again and again. The infant usually does not appear particularly ill. Monrad says that the child suffering from pain in intussusception is remarkably pale and has a characteristic apathetic facial expression that is almost typical. Occasionally the pain is so severe that the infant appears in a state of collapse, emitting now and then a feeble moan, which times the occurrence of the pains.

The late Dr. Amos Abbott of Minneapolis, a keen observer whose experience in the surgery of children was considerable, wrote as follows concerning the pain of intussusception: "These recurring pains with periods of relief, the writer regards as the most conspicuous and unmistakable of symptoms. The outcries accompanying the pains are peculiar and vary from a little cry or grunt to a subdued moan. I have never heard one of these little ones scream. Especially noticeable are their grotesque gestures and postures, such as creeping about with the hands on the abdomen or boring into the pillow with the head, the child taking the knee-chest position, the child may roll face down on the floor or throw itself across its mother's knee. The sudden relief between the pains is equally striking, the pains last from one half to three minutes, rarely more than two, with a longer interval of relief. These pains are almost as regular in periodicity as labor pains."

Vomiting

In his cases, Abbott found that 100 per cent vomited initially, but that in 81 per cent vomiting was not resumed until after the second day. In

patients sent to the University Hospital for operation for intussusception the temporary cessation by vomiting for 12 to 24 hours or more has often been the factor that has led to delay. Continued vomiting is not to be looked for in intussusception, though it may obtain, it is not the usual occurrence.

Blood

Blood and mucus in the stool are almost invariably early occurrences. Clubbe states that in 97 per cent of the cases observed by him blood was passed per rectum in from 2 to 10 hours. The pure colic intussusceptions constantly have blood in the stool early. Enteric invaginations may not present blood in the stool. There is often in intussusception the story of frequent straining and tenesmus with passage of only a little mucus or blood. Rarely blood may be vomited. Monrad noted its occurrence twice in ileocolic intussusception.

The following table gives the frequency and time of appearance of blood in the stool in patients seen by Monrad.

TABLE VII.—TIME WHEN BLOOD WAS PASSED AFTER THE ONSET OF THE INVAGINATION (Monrad)

	Type of invagination			
	Colic	Ileocecal	Enteric	Ileocolic
0-6 hours	19	42	0	5
6-12 hours	1	16	1	2
12-24 hours	1	3	0	6
24-48 hours	0	0	0	5
No blood passed	0	5	5	1
Total number of cases	21	66	6	19

The state of the bowels prior to the onset of intussusception is usually quite normal, occasionally, however, invagination occurs when the infant has recently been having diarrheal stools.

Tumor

An abdominal tumor may fail of being demonstrated though in the majority of instances its presence can be detected. At the London Hospital Perrin and Lindsay state that the occurrence of a palpable tumor was noted in 63 per cent of 400 cases. The ileocecal group presented palpable tumors in 74 per cent, the colic in 73 per cent, the ileocolic in 60 per cent, and the enteric, in only 29 per cent. When anesthesia is employed to obtain abdominal relaxation, the number of instances in which a tumor is palpated is very much increased. Monrad demonstrated its occurrence in all but six out of 112 cases. Clubbe states only twice in the 253 operations that he has done for intussusception has he opened the abdomen without having previously palpated the tumor. In ileocecal invaginations, a tumor is usually felt as a banana shaped area lying to

the right of the umbilicus, stretching up toward the right costal margin, it may, however, be present on the left side of the abdomen, as is usual in ileocolic invaginations or may be palpated by digital examination of the rectum, imparting to the examining finger the consistency of the uterine cervix. In colic invaginations, the tumor is usually found on the left side of the umbilicus in line with the descending colon. Enteric invaginations are always short, small, and very mobile tumors lying in the neighborhood of the umbilicus. If the tumor is concealed beneath the liver or concerns the splenic flexure, and particularly the latter, it may be exceedingly difficult to palpate it even under anesthesia. Abbott felt a tumor per rectum in 55 per cent of his cases. Not infrequently it may be felt directly inside the external sphincter and occasionally the bowel may protrude through the anus.

The tumor of intussusception stiffens with the painful seizures and relaxes when the peristaltic rush is over. With succeeding colics, it advances in position and increases in size. Abbott believes that tumor formation is an early development in intussusception and states that he observed it as early as three hours after the occurrence of pain in a physician's child. The rectal administration of 1 to 15 grams of chloral-hydrate to infants in whom the presence of intussusception is suspected, is recommended, particularly where the tumor is not readily palpable. This procedure increases significantly the number of palpable tumors, in that, it affords a grade of relaxation that is remarkable.

The abdominal wall is usually soft in intussusception but may become moderately rigid during the painful seizures, a voluntary rigidity due to contraction of the muscles of the abdominal parietes. The absence of tenderness and rigidity is explained by the fact that, the ensheathing layer retains its blood supply, even though the intussusception be gangrenous. Distension is a late sign of continued obstruction. The abdominal tumor is best palpated in the quiet interval, the alternating consistency of the tumor is very suggestive of its nature. At the height of the colic, borborygmi may also be made out on stethoscopic examination of the abdomen.

G. DIAGNOSIS

The occurrence of seizures of abdominal pains in an infant accompanied by vomiting and attended by rectal tenesmus and the appearance of mucus and blood in the stool or upon the examining finger inserted into the rectum, and the associated presence of a palpable abdominal tumor varying in consistency establishes the diagnosis. In most infants the clinical picture is usually quite typical, in older children and adults in whom a definite cause in the way of a tumor, Meckel's diverticulum or an ulcer may be found in the bowel, atypical manifestations with an insidious onset or chronic course are more likely to occur.

If the mother's story is attentively heard and care is exercised in examining the abdomen, the rectum and the motions of the infant, an early diagnosis should be made almost invariably. Too often further developments are awaited even though when the physician first sees the infant he suspects an intestinal invagination. When the vomiting abates,

mother and physician alike are deluded by this seeming improvement into believing that the condition is becoming spontaneously corrected. Persistent blood in the stool, abdominal distension, and manifest progressive decline of the infant as expressed in its appearance compel the diagnosis. Such occurrences reveal the frequency with which hope triumphs over knowledge. An early surrender of sanguine trust to judgment in such instances will save many lives and the attending physician considerable distress and embarrassment.

In a well established invagination the lumen of a segment of the bowel within another can occasionally be made out on an x-ray film of the abdomen (Fig. 130). Abbott states that he was able in almost every instance to visualize an oblong mass in the abdomen with the fluoroscope. When the intussusception protrudes into the colon the administration of a barium enema indicates the site to which the invagination has progressed the column of barium being arrested in its progress by the advancing intussusception. A central non-filled area in the intestinal lumen of the most proximal penetration of the barium corresponds to the intussusception. The presence of gas in the proximal small intestine of these infants is of no particular significance for it appears to be a normal occurrence up until about three years of age.



FIG. 130.—Demonstration of intussusception by roentgen examination. Coils of small intestine can be visualized in the ascending colon.

The diagnosis of intussusception can be almost invariably made early by a careful elaboration of the history and critical evaluation of the physical findings. X-ray evidence is to be looked upon as an ancillary aid that is not essential to the diagnosis but which may be of great value in atypical cases. With the exception of enteric invaginations reliable information may be obtained by the rectal administration of barium in most instances. In any case, in which the diagnosis remains in doubt, a barium enema should be given. In the colic, ileocecal, and ileocolic varieties, a filling defect in the colon becomes apparent. In the enteric variety unfortunately no information is obtained by its employment and it is just in this type of intussusception that help is most needed for the appearance of blood in the stool is a late occurrence and the tumors being small are often not palpated.

II. CHRONIC INTUSSUSCEPTION

Inversion of the bowel does not uniformly eventuate in acute obstruction and strangulation of the telescoped segment of bowel. Congestion and edema are the factors that produce obstruction and strangula-

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The abdominal wall is usually soft in intussusception but may become moderately rigid during the painful seizures, a voluntary rigidity due to contraction of the muscles of the abdominal parietes. The absence of tenderness and rigidity is explained by the fact that, the ensheathing layer retains its blood supply, even though the intussusception be gangrenous. Distension is a late sign of continued obstruction. The abdominal tumor is best palpated in the quiet interval, the alternating consistency of the tumor is very suggestive of its nature. At the height of the colic, borborygmi may also be made out on stethoscopic examination of the abdomen.

G DIAGNOSIS

The occurrence of seizures of abdominal pains in an infant accompanied by vomiting and attended by rectal tenesmus and the appearance of mucus and blood in the stool or upon the examining finger inserted into the rectum and the associated presence of a palpable abdominal tumor varying in consistency establishes the diagnosis. In most infants the clinical picture is usually quite typical, in older children and adults in whom a definite cause in the way of a tumor, Meckel's diverticulum, or an ulcer may be found in the bowel, atypical manifestations with an insidious onset or chronic course are more likely to occur.

If the mother's story is attentively heard and care is exercised in examining the abdomen, the rectum and the motions of the infant, an early diagnosis should be made almost invariably. Too often further developments are awaited even though when the physician first sees the infant he suspects an intestinal invagination. When the vomiting abates

timately intermingled and the stool has a pronounced fecal odor. Both fever and constitutional disturbance are marked from the onset of the illness in enterocolitis.

Henoch's purpura must be differentiated. The subjects of purpura are usually older than those of typical intussusception and other evidences of purpura such as a rash, joint pains, hemarthrosis or hematuria are usually manifest. This disease is frequently associated with abdominal pain, vomiting, diarrhea and melena. The constitutional symptoms usually overshadow the abdominal features, however, and the blood in the stool is intimately mixed with the feces. It must not be forgotten that intussusception may occur during its course. Sutherland was the first to call attention to this occurrence and recorded an instance in which a boy of five with purpura was subjected to laparotomy and only a small hemorrhage was found in the bowel and another of a girl of seven with purpura in which the presence of intussusception had not been suspected and the girl died. One might suspect that the presence of an abdominal tumor should differentiate but in a later paper Sutherland refers to two cases in which tumors were palpated, laparotomy done but no intussusception found. Osler was the first in this country to direct attention to the simulation of intussusception by purpura. Gamstedt has recorded the instance of a 17 year old girl for whom he successfully resected 130 centimeters of the ileum for intussusception during the course of Henoch's purpura. Bailey (1930) emphasizes the importance of operating upon cases of purpura complicated by intussusception, and reports several successful cases. Schwartzmann (1940) has reviewed the subject recently. The writer has observed bowel obstruction from hemorrhage into the bowel in a hemophilic who responded satisfactorily to suction (1933 Case II V). The Platons (1940) have reported another hemophilic whose obstruction responded satisfactorily to suction.

Appendicitis may give rise to confusion. Under two years when intussusception is frequent, appendicitis is exceedingly uncommon. In appendicitis a tumor does not form nearly as quickly as in intussusception and bloody stools are absent.

Me enteric thrombosis or embolism may occasionally simulate the clinical picture of invagination of the bowel. The age incidence however is entirely different, the majority of instances of mesenteric vessel occlusion concerns adults. A tumor rarely appears in the latter and bloody stools are also less frequent.

In differentiating rectal prolapse from ileocolic invaginations in which the bowel actually protrudes from the anal canal, an important differential point is that in the former the digital finger can not be inserted between anal canal and protruding bowel, whereas in intussusception the examining finger may enter the anal canal just peripheral to the protruding bowel.

J TREATMENT

The treatment of election is early reduction of the invagination by operation. The abdomen should be opened under inhalation anesthesia

tion of the bowel. Occasionally, the blood supply of the bowel is not vitiated, obstruction is incomplete or absent, resulting in the establishment of the condition of chronic intussusception. It occurs more frequently in adults and often in the presence of a tumor or a Meckel's diverticulum that serves as the entering wedge for the development of the invagination. Instances where a known etiologic agent, such as a tumor or Meckel's diverticulum, are causative, are called secondary intussusceptions. Primary chronic invaginations (without apparent cause) also occur and at all ages. Goodall has collected from the literature 122 chronic primary intussusceptions in adults, of which number 32 had existed for more than six months, eleven, Goodall stated, had been present for more than one year. Pohl relates the remarkable instance of a boy who died of a chronic intussusception which the author conjectures had been continuously present for as long as eleven years. Barlow and Mottershead (1941) report a successful partial colectomy for chronic intussusception in a patient aged 44. They state it as their belief that the intussusception began in childhood.

The symptoms of chronic intussusception are usually atypical. In the majority of instances, however, the onset is abrupt as in acute intussusception. Still and Stallman have particularly stressed this feature. In Goodall's series, the onset was acute in 86 per cent of the cases, attending sudden occurrence of abdominal crampy pain, there was nausea and vomiting. There may be a little blood and mucus in the first motions or these features may be absent altogether. The presence of a tumor that hardens during the pains and relaxes in the free interval should serve to identify the disorder. A tumor was palpable in 88 per cent of Goodall's series. In the recorded cases wasting has been a prominent feature. Visible peristalsis and hypertrophied coils of bowel palpable through the abdominal wall are not uncommon.

Enteritis or tuberculous peritonitis have been frequent diagnoses in chronic intussusception in children, in adults, appendicitis and carcinoma of the bowel as well, are common diagnoses. The sudden onset and the varying consistency of the tumor should serve to enable a careful observer to make the correct diagnosis in most instances. The administration of a barium enema should prove helpful in doubtful cases when the invagination concerns the colon.

In 43 of the instances of intussusception occurring in adults, collected by Eliot and Corscaden, spontaneous separation of the intussusception occurred. A number of these died later, however, of obstruction due to secondary stricture. Goodall believes that spontaneous separation is more likely to occur in acute invagination.

I DIFFERENTIAL DIAGNOSIS OF ACUTE INTUSSUSCEPTION

Enterocolitis may be mistaken for intussusception. In the latter, the passage of blood and mucus by rectum is usually small in amount and frequently has no fecal odor. In intussusception blood is not mixed with the stool as in enterocolitis, in which disease blood and feces are in

to permit delivery of the cecum into the wound. Often considerable pressure has to be exerted before the very last portion unfolds itself. Occasionally a gentle but firm squeeze applied directly over the remaining tumor mass enables the surgeon to complete the reduction with greater ease. Just when to leave off squeezing is difficult to decide. Tears in the peritoneal coat in the bowel, in difficult reductions of an edematous intussusceptum, are not infrequent. Reduction, however, gives much better chance of success with less risk than recourse to resection. The slits in the peritoneal coat may be approximated with a fine suture.

When the interval following the onset of the disease has been relatively short, reduction of the intussusception is ordinarily accomplished with ease. When strangulation has been present for a long time, reduction may be impossible. In such instances, the bowel must be dealt with in some other manner. When the bowel is no longer viable, excision of the devitalized segment with the establishment of a lateral anastomosis is to be done. The fact of the matter is, however, that infants in whom the disease occurs with predilection, rarely tolerate excision and lateral anastomosis. Up to 1913 Dowd found only 8 cases of successful resection of the intestine for nonviable irreducible intussusception in children under one year of age. In the 29 cases necessitating resection in the series of 400 cases of invaginations reported by Perrin and Lindsay, only 9 recovered, all of these patients being more than 3 years of age. In his splendid monograph on intussusception Clubbe (1921) states that 10 successful resections for gangrenous or irreducible invaginations in children under one year are known. (See below.) Goldman and Elman (1940) describe instances of spontaneous reduction of intussusception and collect 30 cases from what they regard as an incomplete survey of the literature. It is not an occurrence which should suggest delay, in a typical instance of intussusception.

In 1906, Rutherford made a lateral anastomosis and left the irreducible intussusception in a 4 months' old infant. Recovery followed. Parry and Bullock have each reported similar successful cases in infants. Sir Harold Stiles in discussing Parry's case referred to his procedure as a "remarkable and great operation." It would appear that where feasible, it should be attended by much less risk, especially if the anastomosis were done with a Murphy button or other aseptic type of technique. In event one feared further advance of the intussusceptum, blocking the stoma, a few stitches could be placed anchoring the entering and encircling layers. Montgomery has also more recently endorsed this procedure.

In adults in whom intestinal fistula is better tolerated than in infants the best procedure in the treatment of gangrenous intussusception is excision of the non viable bowel with anchorage of the open ends in the wound. The continuity of the bowel can be established subsequently with greater safety when obstruction is not present. In an irreducible and gangrenous intussusception in an infant of 4 months the writer exteriorized the bowel and cut away the telescoped bowel after closure of the skin. An extracutaneous end to end union of the bowel was then made. It was proposed to return the bowel to the peritoneal cavity after a few

through a short right rectus incision placed a little below the umbilicus, no matter where the tumor presents. A short incision permits of easy closure of the abdomen after reduction of the intussusception and entails no risk of secondary evisceration due to interference with healing during convalescence. The intussusceptum is to be pushed backward from below, only the most gentle and delicate traction being exerted on the invaginated bowel toward completion of the reduction if necessary. The initial portion of the reduction is done within the abdomen, guided only by the

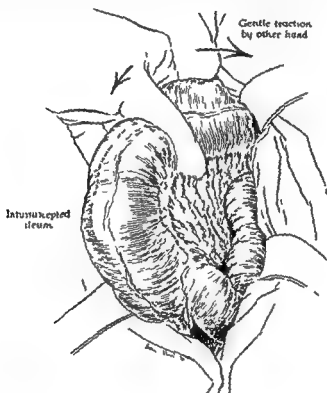


FIG 131.—Operative reduction of intussusception. No traction is put on the ileum but as the intussusceptum is pushed out gentle traction on the ensheathing cylinder facilitates reduction.

sense of touch. Compression is exerted upon the intussusceptum from below with two fingers of the hand within the abdomen and the pressure of the other hand applied upon the external surface of the abdominal wall. Unless the intussusceptum is irreducible it may be pushed back with ease by this means, as far as the cecum. When the intussusceptum can not be pushed back in this manner, the incision must be lengthened and the intussusception delivered upon the abdominal wall. The bowel has to be returned to the abdomen, however, in order to permit reduction at the splenic and hepatic flexures of the colon. The reduction of the apex of the intussusceptum at the cecum is the portion of the invagination that is most difficult and should always be done under direct vision (Fig 131). Occasionally, the incision will have to be lengthened somewhat

Primary resection, granted that the condition of the patient is satisfactory, would appear to be a better procedure

The method of Jésset of dealing with irreducible invaginations in which a longitudinal incision is made in the ensheathing layer, the intussusceptum delivered and amputated and the adjacent cut ends approximated, has little to commend it. The danger of peritoneal infection is far too great. A method that would appear to possess some merit, in the treatment of irreducible intussusceptions in which no serious circulatory effects are present, is the suggestion of H. P. Brown of Philadelphia. He cuts the neck of the ensheathing cylinder with a bandage type of scissors, which division usually permits of extrusion of the remainder of the intussusception. The resulting longitudinal incision is closed by simple suture. The writer has never practiced this method and would prefer to do a primary closed resection, in irreducible intussusceptions. In a recent paper, Capelle suggests that division of the mesentery of an irreducible intussusception may permit reestablishment of intestinal continuity by reducing edema. He would then fasten the neck of the intussusceptum but reports no cases.

The following table gives the type of operation with the operative mortality in the 400 cases observed at the London Hospital and reported by Perrin and Landsay.

TABLE XLII—OPERATIVE MORTALITY OF INTUSSUSCEPTION

	Cases	Deaths	Mortality Per cent
Laparotomy with reduction	309	69	22.3
Reduction with appendectomy	18	0	33.3
Resection with anastomosis by clamps*	29	20	68.9
Laparotomy attempted reduction of anastomosis sewn up	12	12	100.0
Resection with Pauls tube	12	12	100.0
Resection with Murphy button	6	6	100.0
Pauls tube	4	4	100.0
No operation			
Resection { Pauls tube Anastomosis	2	2	100.0
	400	139	34.75

* The 11 cases which recovered were all over 3 years of age

K THE BLOOD LOSS FACTOR

It is to be borne in mind that intussusception is a strangulating obstruction in which the loss of blood into the infarcted segment is an item of real importance. In all patients, with intussusception, this factor must be taken into account. In instances in which the invagination has been present for more than 24 hours, this item attains major importance, for the blood loss may be large in amount. If the pulse is hurried it may be taken for granted that arrest of venous outflow from the strangulated segment has isolated enough blood locally to cause actual or potential shock. No patient with intussusception should be operated on, therefore,

days, the anastomosis in the meanwhile having apparently healed. About the fifth day it broke down, however, and shortly a complete fistula was present (Fig 132). It was astonishing to see how little fluid was discharged through the fistulous opening in this infant. Not uncommonly the drainage assumed the character of a normal stool of a milk-fed baby



FIG 132—Exteriorization of the terminal ileum for irreducible and gangrenous intussusception in a four month old infant. Remnants of the yeast dressing are seen on the abdominal wall. The patient convalesced satisfactorily after closure of the fistula. (See text.)

of that age. When the fistula was closed a few weeks later, its site was found to be about six centimeters from the cecum. The infant convalesced uneventfully. This experience would suggest that even infants may tolerate well intestinal fistula of the terminal ileum. This procedure of exteriorizing the terminal ileum has since been performed successfully in another infant. It may prove that this is the safest procedure for infants with late intestinal invaginations which require radical surgery.

The prejudice against the establishment of intestinal fistula in infants may arise largely from instances in which it has been necessary to do a resection in the

upper reaches of the ileum. Dr. F. H. Scott, Professor of Physiology at the Medical School of the University of Minnesota, tells me that not over 350 cubic centimeters of intestinal secretions pass the ileocecal sphincter in a 24 hour period in an adult. Intestinal invaginations necessitating radical surgery would, on the whole, be suitable cases for the establishment of such a fistula in that the irreducible portion usually concerns the very terminal ileum. Bauer, from the clinic of Leriche, has recently endorsed this procedure and reports two successful instances—neither of which, however, was an infant.

The closed anastomosis should make lateral anastomosis or primary resection in irreducible intussusception a feasible procedure. In an irreducible gangrenous intussusception, in an infant of two months my associate, Doctor Clarence Dennis, performed recently, a successful primary resection employing the aseptic end to end anastomosis. The irreducible portion of the intussusception concerned the terminal ileum. Alberts (1941) resected the strangulated intestine successfully, employing the open anastomosis in a newborn infant with intussusception.

An alternative procedure, in certain cases of irreducible intussusception would be to drain the proximal bowel by enterostomy. In a compound invagination having its origin up some distance in the ileum it probably would be wise to place another catheter into the distal bowel for purposes of re-introducing the escape from the enterostomy drainage. Mayo and Phillips report the use of this method. The method would appear to have very limited usefulness. It leaves too much to chance.

were received with a good deal of skepticism. The chairman of the section questioned the possibility of successfully reducing 50 to 60 per cent of intussusceptions without operative intervention.

Monrad, Hirschsprung's successor at the Queen Louise Hospital in Copenhagen, has been an equally ardent advocate of this method of reduction. Of 84 cases in which taxis alone was tried, 72 were cured and 12 died—a mortality of 14.3 per cent. With regard to the duration of the invagination, Monrad abides by the following rules in attempting taxis. Reduction may be attempted up to 36 hours for the pure colic form, not after 24 hours in the ileocecal, and not after 12 hours in the enteric variety. Monrad advised against attempting reduction in instances of ileocolic intussusception. The correct recognition of the type of intussusception present is important when the conservative method of taxis is attempted.

Olsson and Pallin have reported 4 cases of intestinal intussusception in children, in 3 of which a reduction was obtained by administration of a barium enema. Monrad employs chloroform anesthesia and combines manipulation of the abdominal wall and administration of an enema.

Hirschsprung employed a combination of enemas and taxis under chloroform anesthesia and when a first attempt was not successful, he tried it a second and third time. Monrad makes only one attempt and only for 5 to 10 minutes, grasping the neck of the invagination with both hands, he then compresses it from one to two minutes to diminish the edema and then holds the neck of the intussusception with the left hand and tries with the right to pull the intussusception back through the intestine.

Almost without exception our textbooks of surgery and treatises on the surgery of infancy and childhood condemn the non operative method of reduction as dangerous. Recently however Hipsley of Sydney, who to date may boast as good operative results in the treatment of intussusception as have been published has given the non operative method a trial. He states that hydrostatic pressure has not only a decided place in the treatment of intussusception, but that it is absolutely wrong to submit any patient to operation before attempting to reduce the intussusception by injection. Out of 105 cases in which Hipsley attempted reduction with hydrostatic pressure, the method was successful in 62, of which number only 1 died. He employs water at a level of three feet, six inches (105 centimeters).

In the method employed by Olsson and Pallin is afforded a visual corroboration of satisfactory reduction—the 'Achilles' heel' of the manual reduction method, in which the expulsion of a stool must be awaited for confirmation of successful reduction. Arntzen and Helsted have reported also employment of the method with success as have Stephens and others. Nordentoft (1939) states that reduction of intussusceptions by barium enema is finding increasing favor in Denmark.

With the co operation of Dr L. G. Rigler the writer has had occasion to test the efficacy of the method in a number of instances. The late intussusceptions which afford the surgeon difficulty in reduction, the

until the blood volume has been restored by transfusion of blood or plasma in adequate amounts. In this clinic, the restorative value of such transfusions in late intussusceptions has been demonstrated on a number of occasions (See discussion pages 51-55 and page 134.)

L MORTALITY

Of the 253 operations performed by Clubbe of Sydney, there were 54 deaths, a mortality of 21.3 per cent. Only 8 or 2.2 per cent of all the cases in the series were over two years of age. The mortality in the third 50 consecutive cases was 8 per cent, and of the fourth 50 cases, only 8 per cent. Taylor of Dublin has reported 81 operations for intussusception with only 3.7 per cent mortality. Page reported from St. Thomas Hospital in London at the same session of the British Medical Association only 9 deaths in 102 operations for intussusception—a mortality of 8.9 per cent. These greatly improved mortality rates indicate what results may be obtained with early recognition and operative relief. Hipsley of Australia has had 51 successful operations without mortality in cases that submitted to operation when not more than 36 hours had elapsed from the onset of the attack. In Hipsley's series there were 4 deaths, 1, in which more than 36 hours had intervened from the onset, 2, in which the intussusception had been present 3 days, and 1, for 4 days. The experience of this writer justifies the statement that all cases submitted to operation early, recover. Restoration of the blood volume before operation by transfusion and use of the closed method of intestinal anastomosis, in practiced hands, should bring about considerably better results in the late cases.

M POSTOPERATIVE FEVER

Following the reduction of the intussusception, a large number of the late cases run an unusually high fever as compared with other intra-abdominal operations for the first few days. In the London Hospital series of Perrin and Lindsay, 56.1 per cent of the ileocecal and 41.9 per cent of the ileocolic cases exhibited a temperature of 101°, while a temperature of 102° was reached in 38.7 per cent of the ileocecal and 28.2 per cent of the ileocolic cases. The edema in the wall of the intestine and the liberation of a toxic substance from a damaged bowel wall Perrin and Lindsay felt to be the causative agents in this pyrexia. The writer's impression is that such reactions suggest that the viability of the bowel has been seriously threatened.

Unless the patient is an infant an indwelling duodenal tube to which suction is applied, should be used for a few days postoperatively. Infants do not tolerate well, the presence of an indwelling duodenal tube, because of the hazard of middle ear infection (see page 171).

N NON OPERATIVE REDUCTION

Hirschsprung gained world wide renown for successful reduction of intussusception by the non-operative method. He presented his material in 1903 at the German Surgical Congress where the results of his method

the region of the ileac fossa Cohen reports 4 instances of recurrent invaginations in infants, all under eleven months of age at the time of the first attack, all recovered. He referred to 17 other instances reported in the literature.

Most of these recurrences did not occur in the same hospital admission. Usually the same segment of bowel was concerned, occasionally the recurrence was at a different level. Clubbe believes the likelihood of recurrence is so unusual that it is unnecessary to anchor the cecum at the initial operative procedure but recommends its performance for recurrent invaginations involving the cecum. It has also been suggested that the terminal ileum be stitched side to side to the cecum to obviate the propensity for the ileum to prolapse into the large bowel (Lamson). In those instances where the mesentery of the small intestine appears unduly long and mobile, resection and plication have been suggested. In the reduction of every acute intussusception many writers have called attention to the importance of pressing out the last cup-shaped depression at the apex of the intussusceptum which represents the starting point of the invagination. This concavity must be gently pressed out and made convex. At operation one may occasionally observe a tendency of the bowel to reinvaginate when this dimple is not squeezed out.

Most frequently, however recurrent intussusception concerns older children and adults in whom a tumor or a Meckel's diverticulum is the existing factor in the production of the invagination. In an edematous bowel following reduction of the invagination small tumors within the bowel are easily overlooked. Barrington Ward cites an instance in which a girl of six had been operated upon four times for the reduction of an enteric intussusception. At the fifth operation he resected the telescoped bowel and found several tumors in the segment. Oughterson and Cheever refer to a patient aged 22 who had four times been admitted to hospital with abdominal pain. In one of these admissions an intussusception of the ileum was operatively reduced, on the fourth admission, a resection was done and a lipoma was found at the apex of the intussusception. They refer to 12 other such cases reported in the literature including the case of Barrington Ward referred to above. Haggard and Floyd record a most unusual instance in which a patient had one reduction of an intussusception and three subsequent intestinal resections for intussusception caused by an adenoma of the bowel. A sister of this patient had two intestinal resections and the father three because of gangrenous intussusception.

In every invagination occurring after two years of age the presence of a tumor or a Meckel's diverticulum is to be considered. Rexwald Brown records the excision of a segment of intestine for intussusception in a 21 month old infant multiple polyps being found in the excised segment. Shaw (1939) has reported recently five additional cases of intussusception occasioned by polyps. Repeated attacks of partial obstruction are often to be elicited in the history. Inasmuch as the small intestine is so frequently concerned no blood may appear in the stool and a tumor may not be palpated (Lower).

barium enema will frequently chase back, but complete reduction by this means is most unusual. It is the writer's impression that in such cases it is scarcely worth while to try it, by the time that the patient comes to operation, a short time later, the intussusception has again advanced to its previous position. It is in the early cases that the method has virtue, a few such cases have been successfully treated by the writer with this expedient of conservative reduction with barium controlled by fluoroscopic visualization. In this clinic, however, the abdomen is opened to make certain that the intussusception has been reduced completely and to exclude the presence of a compound intussusception (Fig 133). Should one, however, be dealing with an instance of compound intussusception, the filling out of the cecum and regurgitation of barium into the small intestine might cause the examiner to wrongfully conclude that the intussusception had been completely reduced. This hazard is a real one, to be certain, observation for an hour or two might help to avoid the pitfalls of this error.



FIG 133—Reduction of intussusception by barium in an infant. Visualization of barium in the small intestine indicates that the intussusception has been reduced. It does not exclude a compound intussusception, however.

Yet this contingency should occasion anyone who undertakes to treat intussusception conservatively by this means some misgivings over its safety. Taxis and other rough methods of manipulation through the abdominal wall are not to be recommended.

Clubbe employs the enema only as a preliminary measure. He finds that in most instances, the bowel may be pushed back to the region of the cecum by its employment, but he feels it unsafe to rely upon it for complete reduction. Complete reduction without operation he has accomplished in only 10 per cent of his cases. The child is on the table ready for operation and 300 cubic centimeters of water under a feet gravity pressure is allowed to run into the rectum. If any doubt exists concerning complete reduction of the tumor, the abdomen is opened.

O RECURRENT INTUSSUSCEPTION

The recurrence of an acute intussusception is not frequent. Clubbe states that he has twice had to re-operate for recurrent invagination in infants. Barrington Ward (1928) refers to an instance in which 3 recurrences took place. Hipsley records the remarkable instance of a child of 5 months operated upon three times within three weeks, each time the apex of the intussusceptum was found to be the tip of the cecum, and on the last occasion Hipsley stitched the cecum to the parietal peritoneum in

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CHAPTER XXII

ERRORS IN DEVELOPMENT OF THE INTESTINE GIVING RISE TO INTESTINAL OBSTRUCTION (OTHER THAN CONGENITAL STENOSIS)

Embryology A Anomalies of Rotation

IN THE natural orderly development of the bowel and its mesentery, a number of accidents may occur which may lead to subsequent intestinal obstruction. Among these are to be enumerated (1) partial or complete exomphalos or hernia of the umbilical cord due to lack of final fusion of the abdominal walls, (2) persistence in part or in whole of the vitello intestinal duct (Meckel's diverticulum), (3) abnormalities of rotation of the gut (4) inadequate fixation particularly of the small intestine, the bowel being suspended by a narrow pedicle of mesentery a condition permitting abnormal mobility and predisposing to torsion and (5) persistence of holes or defects in the mesentery. This latter occurrence has been discussed previously under the caption of Internal Hernia.

The process by which the intestine develops its lumen has already been described in chapter XI. It may be well for a better understanding of the hazards connected with the assumption of the ultimate position of the bowel to briefly trace here the normal process by which means this end is attained. Dott and Keith give unusually lucid descriptions from which accounts the following has largely been derived (Fig. 134). The first indication of the alimentary canal is the endodermic vesicle. Very early a constriction in the vesicle demarcates the future alimentary canal and its appendages from the extra celomic portion in the yolk sac. The vitello intestinal duct establishes the communication. With elongation of the embryo the alimentary canal assumes the form of a tube and its subdivisions become apparent. The primitive intestinal loop lies at first in a single plane and is suspended by a common dorsal mesentery. In the fifth week of fetal life the midgut has become a V shaped tube and shortly later assumes the form of a U loop. The midgut loop is divided by the vitelline duct into two segments: 1) the prearterial segment embracing the greater part of the small intestine lying proximal to the duct (Meckel's diverticulum) and 2) the postarterial segment from the vitelline duct to the point of juncture of hind and midgut at the mid transverse colon. As the blood vessels of the placenta develop lack of further need for the yolk sac causes it to shrivel and the intracelomic portion of the vitello intestinal duct disappears normally at about the sixth week. Persistence of the duct leads to the occurrence of Meckel's diverticulum. While the U loop of the midgut is still in the umbilical cord in the extra celomic position due to its more rapid growth as contrasted with the hindgut, the intestine assumes an S shaped curve the small intestine lying on the right and the colon on the left. Further, the prearterial segment—the small intestine grows

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testine has been attained. This marks the completion of the second stage of intestinal rotation, the midgut loop now having twisted in a counter-clockwise fashion on the axis of the superior mesenteric artery through 270° from its original sagittal plane. The third and final stage of rotation consists essentially in descent of the cecum and the attainment of normal mesenteric fixation of the entire bowel. The mesentery of the colon becomes largely obliterated, the last parts of the bowel to become fixed are the ileum and cecum. The small intestine, previously suspended by a narrow pedicle of the superior mesenteric artery, now acquires a wide fan-like attachment at the root of the mesentery, owing to fusion of the mesenteries with the posterior parietal peritoneum. This phase of intestinal rotation provides protection against volvulus. Failure of this fusion to occur invites volvulus. The cecum persists in the fetal position over the right kidney until birth when it comes to lie in the iliac fossa. This position of the cecum is a feature occurring only in primates adapted to the upright posture (Keith).

Pathogenesis

Anomalies of intestinal rotation concern essentially the second stage of rotation. Dott points out that derangement of the first stage of rotation occurs only in the rare condition of extroversion of the cloaca. Development of all structures formed from the primitive gut caudal to the vitello-intestinal duct is interfered with and the post-arterial segment of the midgut loop remains undeveloped. Rotation fails to occur and the pre-arterial segment—the small intestine—retains its primitive position, ventral to the superior mesenteric vessels.

Dott classifies derangements of the second stage of rotation into three groups:

- (1) non rotation of the midgut loop
- (2) reversed rotation of the midgut loop
- (3) malrotation of the midgut loop

The first, non rotation, is not a rare anomaly and most clinics which are alert to its occurrence have seen several cases. The entire small intestine lies on the right side of the abdomen and the colon on the left. This occurrence serves to identify the condition either on the roentgen film or at operation. The duodenal loop may have attained its normal retro-mesenteric position. In the typical instance of complete failure of rotation however the duodenum passes downward and to the right from the pylorus lying to the right of the superior mesenteric artery. The tendency is for incomplete fixation of the mesentery of the small intestine and ascending colon predisposing to volvulus. Despite the aberrant position of the small intestine and the right colon in the experience of the writer the colon from the splenic flexure down has been normal in its disposition.

Reversed rotation of the midgut loop according to Dott is an extraordinarily rare condition. The rotation of the small intestine occurs through 90° in a clockwise direction. In consequence, the transverse colon comes to lie behind the superior mesenteric artery close to the origin of the vessel, and the duodenum lies anterior to the superior mesentery artery at the

more rapidly than the post-arterial segment—the cecum, with the consequence that the small intestine and its mesentery become considerably more elongated. This completes the first stage of rotation.

Definite jejunal and ileal coils become apparent in the umbilical cord at

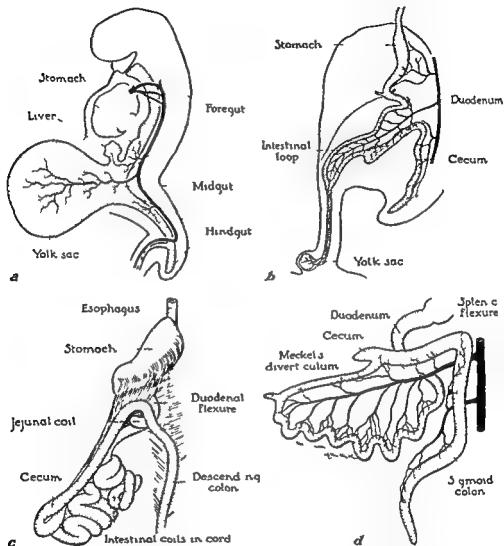


FIG 134—Stages in the development and rotation of the intestine (a) The form of the alimentary canal in a human embryo at the fourth week (b) The alimentary canal and its mesenteries during the sixth week of development (c) The intestinal loop in a fetus in the ninth week (d) Position assumed by the colon after rotation of the gut has taken place (After Keith *Human Embryology and Morphology* Longmans Green & Co. New York 1921)

the ninth week. About the tenth week, the midgut returns from the umbilical cord to the abdomen. The cecum is the last to return to the peritoneal cavity of the fetus, and as it does so, the colon is carried forward over the superior mesenteric artery of the midgut loop, and at about the eleventh week, the normal postural relationship of the colon to the small in-

same point Dott was familiar with only two cases which fitted this description. One was his own, the other a case reported by John Hunter. In Dott's case, the small intestine had normal mesenteric relations. The cecum and ascending colon had a free and long mesentery. Volvulus of the cecum had occurred. Dott resected the ascending colon. The peritoneal coat of the cecum had ruptured because of the cecal distension and the patient died. Since Dott's lucid paper (1923) on derangements of intestinal rotation, other cases of this variety have no doubt been published. Peignaux and Fruchaud (1930) report the instance of a young girl in whom the colon was found behind the superior mesenteric artery. In three successive operative procedures they performed (1) anterior gastrojejunostomy, (2) colo colostomy on the transverse colon and (3) colopexy on the right colon.

In malrotation of the midgut loop, Dott placed a group of cases presenting irregular defects of rotation not readily classified. In some instances the prearterial segment—the small intestine—occupies its normal position and the descent of the cecum into the right lower quadrant has not been complete. In others nonrotation of the small intestine is present, with an incompletely descended cecum.

It is not difficult to picture a case which, on the basis of the differentiations made by Dott, one might have difficulty in deciding whether to place in Dott's group I or III. The group II case of reversed rotation in the occurrence of the situation of the transverse colon dorsal to the superior mesenteric artery has a characteristic finding which serves to identify it.

Derangements of the third stage of rotation of the midgut loop have to do with failure of cecal descent with fixation of the cecum in the subhepatic position. On the contrary, however, the cecum may descend but fail to secure fixation in its normal position, resulting in an abnormally mobile cecum with predisposition to cecal volvulus.

Clinical Features of Obstruction Occasioned by Nonrotation

Dott has pointed out the great significance of the duodenocolic junction or the narrow space over which both the duodenal loop and the colon in the process of rotation come in contact with the superior mesenteric artery. Events which occur at this site, are responsible for the types of obstruction which may attend nonrotation and condition the symptoms that may follow. Essentially two kinds of obstruction may occur. 1. Obstruction near the duodenojejunal angle occasioned by abnormal adhesions. 2. Volvulus of the small bowel and cecum and ascending colon or torsion of any segments of these about the superior mesenteric artery, each owing to inadequate mesenteric fixation.

The superior mesenteric artery may lie in front of or behind the duodenum. The adhesions, which may be multiple, constrict the duodenum and may give symptoms in the first few weeks of life suggesting that duodenal stenosis may be present. Enormous ballooning of the duodenum may occur in consequence of the external compression of adhesive bands. The writer has operated upon several instances of duodenal obstruction in which symptoms of periodic obstruction continued from birth into ado-

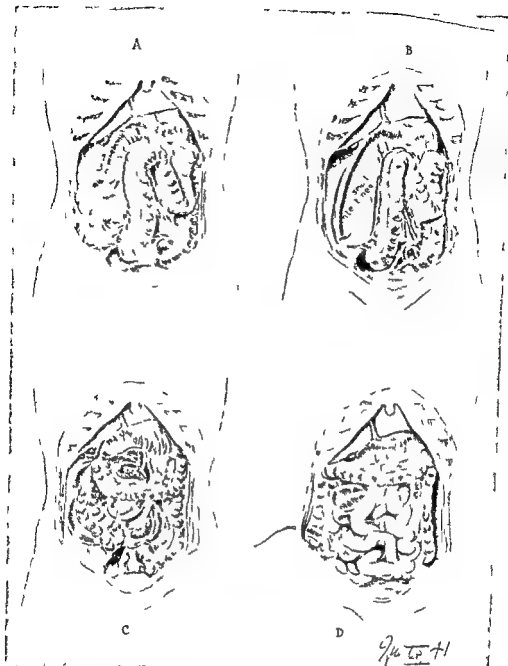


FIG 135—Non rotation of the intestine and the writers operation to correct the defect The x rays before and after operation are shown in Fig 136 The patient had many attacks of obstruction prior to operation He has remained well (a) The condition noted at operation (b) Incisions to permit freeing of large and small intestine (c) The colon has been mobilized a hole has been cut in the transverse mesocolon to permit reposition of the small intestine into its normal habitat (d) The condition on completion of the operation it is to be noted that complete reduction of the small intestine can not be effected without severing the terminal ileum An end to-side anastomosis between the ileum and the cecum is shown A catheter is threaded into the cecum through the terminal closed segment of ileum and employed as a decompressive vent in the recovery period

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lence or even adulthood. The omentum may also be a factor in this compression. Instances have been observed by the writer, in which the omentum went from the stomach to the duodenum—there being no omental attachment between stomach and colon as occurs normally.

Volvulus attending failure of complete rotation may make its appearance in the first few weeks of life and has come to be known as *volvulus neonatorum*. In his paper, Dott refers to five cases of prenatal *volvulus* occasioned by this condition. It is known that the fetus swallows amniotic fluid and that the intestine functions before birth. The thorotrast studies made by Becker, Windle, and their associates (1940) on the fetus of the guinea pig indicate that, thorotrast injected into the amniotic sac of the fetus is swallowed, excreted by the intestinal canal of the fetus and re-swallowed again. The occurrence of prenatal *volvulus* is therefore, understandable.

Periodic attacks of pain may be suffered by patients with defects in intestinal rotation, due to partial torsion. A number of patients may present both aspects of obstruction conditioned by the presence of non-rotation *viz.* duodenal compression and torsion of segments of the mid-gut loop.

Failure of completion of the third phase of intestinal rotation leads to lack of adequate fixation of the bowel and predisposes to the occurrence of *volvulus* especially of the small intestine and cecum. Lack of completion of the second and most essential process of intestinal rotation leads to the condition called non-rotation of the bowel, in which the small intestine occupies the right portion of the abdomen, and the colon the left. Inadequate mesenteric fixation characterizes such cases and they are prone to periodic attacks of pain occasioned by torsion of the gut upon an elongated and inadequately fixed mesentery. Wakefield and Mayo call attention to the fact that the cat's intestine remains in the position of non-rotation. Gardner and Hart have recently collected 105 cases of bowel obstruction which had their origin in imperfect intestinal rotation. *Volvulus* of the bowel is described under a special caption as is also *hernia of the intestine through mesenteric defects*.

Treatment

The writings of Hammond and Dragstedt (1931), Gardner and Hart (1934), Jones and Morton (1938), Miller (1939), McIntosh and Donovan (1939) have helped to clarify the nature of obstruction attending anomalies of intestinal rotation. These papers have served to indicate that the condition is by no means rare. Ladd and Gross (1941) report 44 cases from The Children's Hospital in Boston alone. In instances presenting *volvulus* detorsion must of course be done.

The Writer's Operation for Non-rotation

The matter of securing satisfactory mesenteric fixation in instances lacking normal attachment, is not so simple. In instances presenting non-rotation of the bowel, the writer has in a few instances carried out the



FIG. 136—Roentgen films of non rotation of the intestine before and after operation. A The small intestine lies on the right side of the abdomen. B The colon lies on the left. C After performance of the type of operation shown in Fig. 135. Loops of small intestine lie within the U loop of the colon. D The position of the colon outlined by a barium enema.

operative procedures depicted in Figure 135. An incision is made along the right lateral border of the small intestine and a similar incision just to the right of the right border of the unrotated colon, the colon is pulled over to the right, an incision is made in the transverse mesocolon and the small intestine is returned to its normal position. Finally it becomes necessary to sever the lower ileum and to bring the very terminal segment

of the lower ileum forward from behind the cecum, reanastomosing the ileal segments in the normal position. Latterly, the writer has closed the terminal ileum, employing this segment as a means of decompressing the colon during the early recovery period. In this latter procedure, the proximal segment of the obliquely divided ileum is anastomosed, end to side to the ascending colon. A distinct advantage of this latter procedure, over end to end anastomosis of the terminal ileum is that, no risk of compromising the blood supply of the terminal ileo colic segment is involved. In order to free the terminal ileum adequately to pull it forward from be-



FIG 137—Recurrent and chronic obstruction due to congenital duodenal stenosis of extrinsic origin (Waugh Ladd compression syndrome). This boy, A. B. Univ. Hosp. No. 669772, aged 14, had been subject to frequent recurrent abdominal pain and vomiting. A, The x-ray film before severance of bands compressing the duodenum. B, After the operation. The boy has grown a great deal since operation and has no complaints.

hind the cecum, it may be necessary to cut some of its mesentery. Closing the terminal ileum and establishing intestinal continuity by end to side anastomosis with the cecum or ascending colon circumvents this potential source for trouble. The results attending this type of correction have been very satisfactory. The radiographic end result in a patient in whom this operation was done is shown in Figure 136.

B. EXTRINSIC DUODENAL STENOSIS

Compression of the retroperitoneal duodenum by abnormal bands is related probably to the final stage of rotation of the bowel—mesenteric fixation. As was indicated above, extrinsic compression of the duodenum by abnormal bands may coexist with non rotation. Extrinsic duodenal stenosis has been described in part already in Chapters XI and XVI. The technique of dealing with the condition at operation is indicated in Figure 138. Unlike duodenal atresia, which concerns newborn infants in variably, patients with extrinsic duodenal stenosis may come first for surgical relief during adolescence or even adulthood (Fig. 137).

The writings of Ladd have helped materially to clarify the nature of

the obstruction and the necessary operative maneuvers directed at its relief. A number of us, undoubtedly, performed duodeno jejuno tomy for the relief of this condition before becoming familiar with Ladd's writings on the subject. Ladd has pointed out that, division of the adhesions causing the duodenal compression makes a direct attack upon the bowel itself unnecessary. Rixford (1920) had indicated already that severance of adhesions about the duodenum might rectify the condition and reported

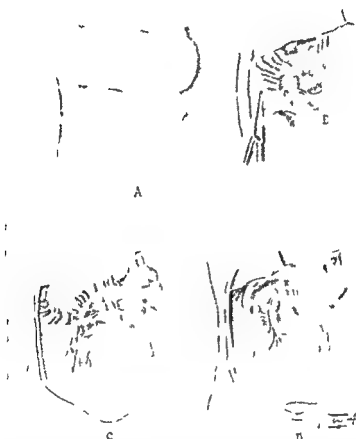


FIG 138—Ladd's operation for extrinsic duodenal tenosis due to compression bands (a) The dilated duodenum sketched from 137A (b) Division of the avascular colic and the cysto-colic ligaments to expose the duodenum (c) Cutting the duodenal compression bands (d) The course of the duodenum after severance of the bands

one such case in a child of 5 years. And Waugh (1928) described the condition as an entity and reported several instances in which a procedure very similar to the Ladd operation of division of extrinsic adhesions compressing the duodenum had been done. Ladd's experience with the operation is summarized in Chapter XI.

C EXOMIALOS (OMPHALOCELE UMBILICAL EVENTRATION)

In part, the difficulty of closing the abdomen, after excision of a large omphalocele may be circumvented by initial closure of the skin alone. At a later date, when the muscles of the abdominal wall have been stretched out incident to replacement of the intestine in the peritoneal cavity, the deeper layers may be approximated. Todd and Gross report a number of two stage closures for the repair of this defect. They found that the size of the sac was an important determinant in the mortality. In sacs over 8 centimeters in diameter, the mortality was 85 per cent. When the diameter of the sac was less than 8 centimeters, the mortality was only 25 per cent.

D MECKEL'S DIVERTICULUM

The persistence of the vitello intestinal duct in man is said to occur in almost 2 per cent of instances. It arises from the free border of the ileum,

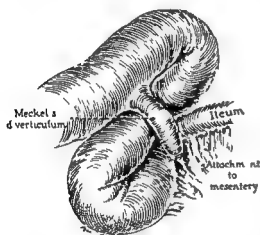


FIG. 139.—Intestinal obstruction due to Meckel's diverticulum: a loop of ileum has been captivated beneath the diverticulum and an adhesive band which attaches it to the mesentery.

usually within 20 to 100 centimeters from the cecum. Kelly found 12 instances of its occurrence among 1446 autopsies, an incidence of 1 in 80 or 0.8 per cent. In no instance was death caused by its presence and no foreign bodies were contained in its lumen. The average distance from the ileocecal valve was 34.5 inches (88 centimeters), the greatest distance was 50.5 inches (127 centimeters) and the shortest, 15 inches (38 centimeters). The average length was 21½ inches (63 centimeters); the longest was 61½ inches (165 centimeters) and the shortest was ½ inch (12 centimeters) in length. In a col-

lective report made to the Anatomical Society of Great Britain and Ireland in 1892, persistence of Meckel's diverticulum may persist as (1) complete pervious external fistula, (2) sinus at the umbilicus, (3) cyst of the umbilicus, (4) enterocystoma, (5) fibrous cord from the ileum to the umbilicus or (6) the differentiated diverticular process from the bowel (Miller and Wallace). In turn the well developed diverticulum may have accompanying remnants of its blood supply, a cord like adhesive band which may go to the umbilicus or to the proximal mesentery of the ileum. Evagination of the bowel with obstruction may occur through a persistent fistula at the umbilicus. The more frequent varieties of bowel occlusion occurring through this agency are (1) simple or strangulating obstruction by a constricting band, (2) intussusception, less commonly volvulus of the

diverticulum alone or including the adjacent ileum may occur. In 326 cases of Meckel's diverticulum collected by Wellington, 212 were obstructed; in 59 intussusception was present; in 9 volvulus; and in the remaining 144 the type of obstruction most commonly present was in the nature of an adhesive band. The impaction of foreign bodies, such as gallstones (Hanke), in a Meckel's diverticulum has been noted, as well as the occurrence of obstruction through feces becoming impacted in it (Bettmann and Blum). Tuberculosis, enterocystomas, pancreatic tissue, carcinoid tumors, carcinoma and sarcoma have all been found in Meckel's diverticulum, some of which conditions have caused bowel obstruction. A partially duplicated ileum has occurred in association with a Meckel's diverticulum. Two rather infrequent non-obstructive surgical conditions of Meckel's diverticulum are (1) the occurrence of gastric glands in its wall with the occurrence of perforation or hemorrhage (Cobb) and (2) diverticulitis. Waugh (1941) and his associates have reported in tances recently in which strictures developed in the intestine opposite a Meckel's diverticulum due undoubtedly to a healed acid ulcer.

Instances of giant Meckel's diverticula have been reported. In this connection a called duplications of the intestinal canal should be mentioned. Some of these are related to remnants of the vitello intestinal duct (Meckel's diverticulum); others are not. Ladd and Gross have reported several instances of this sort. In addition there are enterocystomas of the bowel wall or in immediate relation to the bowel wall having their origin in the adjacent mesentery. The latter are frequently of lymphatic origin. Some of the true enterocystomas of the gut wall represent, undoubtedly, remnants of the vitello intestinal duct. Rea (1940) described a case of enteric cyst in which contractions could be made out over the swelling during peristaltic rushes.

The clinical features of bowel obstruction caused by Meckel's diverticulum participate in the general character of the particular variety of obstruction present and have already been discussed under other captions. Buchanan claims to have made the diagnosis of bowel obstruction due to Meckel's diverticulum by a process of exclusion before operation. Pfahler has twice detected the presence of Meckel's diverticulum on barium study of the small intestine. In the compound entero-enteric colonic intussusception of early childhood, the likelihood of a Meckel's diverticulum constituting the apex of the intussusception is great. The writer has seen two such cases. Montgomery states that the mortality of obstruction caused by Meckel's diverticulum approximates 50 per cent—an indication that in the majority of instances a late strangulating type of obstruction is present. Obstruction due to Meckel's diverticulum is to be treated in accord with the guiding principles of the type of obstruction present, which most frequently is that of an adhesive type of mechanism or of invagination. In the removal of the diverticulum care is to be taken not to narrow the bowel so that stricture will result. Brown records the instance of a gangrenous diverticulum in which he exteriorized the intestinal segment concerned and applied a clamp to its base. A temporary fistula formed which closed spontaneously.

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CHAPTER XVIII

INHIBITION ILEUS (PARALYTIC)

(Adynamic Obstruction)

A PATHOGENESIS

THIS TYPE of obstruction is most often seen in peritonitis. Its occurrence in mild grade following intra abdominal operations of practically every sort is well known. Incident to each operative interference in the peritoneal cavity, a moderate parietic condition of the bowel obtains in which distension and difficulty in expelling gas occurs. As the peritonitis begins to be recovered from dilated loops contract down upon their gaseous and fluid contents and give rise to "gas pains." Reflex inhibition ileus is observed following strangulation of the omentum, in renal attacks not uncommonly (Eisendrath) and less frequently in gallbladder colic, following torsion of an ovarian cyst and strangulation of the spermatic cord a reflex dilatation of the intestine with markedly impaired motor power may obtain. Following blunt trauma of the abdomen prolonged either alone or the 12 (Frey) or even accompanying fractured ribs paralytic ileus may be seen. Following thoracoplasty and especially after excision of lower ribs on the left side inhibitive ileus may follow after injuries of the spinal column and following hyperextension in a plaster of Paris body cast, intestinal distension is not infrequent. Olivecrona has studied the anatomical basis for distensions accompanying trauma and states that inhibitory phenomena are responsible. Embolism and thrombosis of the mesenteric vessels not infrequently give rise to similar distension of the intestine. Retroperitoneal infection, hemorrhage or tumors are occasionally causes of paralytic ileus. In the course of some infectious fevers especially meningitis, pneumonia and septic conditions in general meteorism of severe grade may be seen.

After injury or damage to the central nervous system a varying degree of paralytic ileus may follow as also occurs following injuries of the spinal cord. Joyce relates several instances where the abdomen has been opened for obstruction caused by retroperitoneal hematomas and Sohn refers to two cases of spontaneous perirenal hemorrhage which gave rise to symptoms of intestinal obstruction for which laparotomy was performed in one instance. Demel has demonstrated in animals that, the presence of blood in the retroperitoneal space, especially in the vicinity of the splanchnic nerves gives rise to intestinal meteorism.

It has generally been believed in the distension of the intestine associated with peritonitis and some of the other conditions mentioned that an actual paralysis of the motor power of the intestine exists. Hotz, however demonstrated a number of years ago that loops of intestinal musculature from animals suffering from peritonitis exhibited a fairly normal contractile power and the reaction to stimulation with drugs was normal. This

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periods of time, whether by occlusion of the lumen or inhibitive forces, which interfere with the transport problem of the bowel. In inhibitive ileus as in mechanical obstructions, in early cases, the distension is largely gaseous. Late cases of both varieties exhibit considerable fluid in the bowel. It would appear, therefore, that distension in inhibitive ileus threatens the viability of the bowel wall, just as it does in mechanical obstructions. Bayliss and Starling (1891) pointed out many years ago that the capillaries of the intestinal mucosa are more permeable to protein than are other capillary blood vessels. (See Systemic Effects of Distension, pages 41-44.) When long reaches of bowel are distended, as occurs invariably in inhibitive (paralytic) types of ileus, the loss of plasma is an additional factor to be considered. From the peritoneal cavity such transudations of fluid would be absorbed probably, until its protein content, with increasing injury to the intestinal wall, approximated that of plasma. The influence of great distensions in segregating blood and plasma in the lower extremities has been described already (page 41).

C CLINICAL FEATURES

Extreme meteorism dominates the picture in paralytic ileus. Whereas, in mechanical obstruction, the intestine above the point of occlusion becomes gradually distended, in paralytic ileus, quick dilatation of the entire intestinal tract occurs giving rise frequently to enormous clinical distension. The source of this gas is also largely swallowed air (Hibbard 1936). During cystoscopic examinations and pyelography one not uncommonly is afforded an opportunity of seeing how rapidly air will negotiate the entire length of the intestinal canal. Incident to the distension, considerable respiratory difficulty is often present. The breathing is largely costal in character, superficial and rapid. The pulse is frequently hurried and small. Tenderness over the abdomen is usually present. Very little or no pain may be complained of. On auscultation, the abdomen is relatively silent, only feeble noises being audible. The heart sounds and even the breath sounds may be heard over the abdomen in the presence of considerable fluid in the bowel and in the peritoneal cavity—the explanation being that fluid is a good resonator (Peters). No gurgling or splashing sounds are present. The patient frequently complains of severe thirst but regurgitates all fluid ingested. The urinary output is scant and if fluids are forced by the subcutaneous or intravenous route edema frequently obtains. Despite the obviously dangerous condition of the patient he frequently has no conception of the gravity of his illness. Euphoria is commonly observed. Enemas may be partially expelled with a return of fecal matter and small amounts of gas, occasionally no return is obtained. A scout film of the abdomen usually shows gaseous distension of the entire intestine with layering of fluid between the coils. There are seen now and then to be certain instances of inhibitory ileus in which only a few coils of intestine are distended. Careful integration of clinical and roentgenologic findings, therefore, must always be made. The absence or presence of *intestinal colic* is an important determinant in the diagnosis. Pain is not a usual complaint but occasional intestinal gurgling may be heard.

observation lends tenable support to the belief that, the extrinsic nerves of the intestine play an important role in the motor inhibitions in peritonitis. The *vagus* is the motor nerve of the greater portion of the intestine and the influence of the sympathetic is inhibitory to the bowel but motor to the sphincters. It has been shown by shunting out the influence of the sympathetic, by division of the splanchnics or blocking them with splanchnic or spinal anaesthesia, that the paretic intestine of paralytic ileus can be made to contract (Wagner, Ochsner and associates, and others).

Paralytic ileus is therefore an ill chosen name for the meteorism and motor inactivity observed in the conditions enumerated above. The intestine is not paralyzed, its activity is inhibited and restrained by an overactive sympathetic influence. In chemical iodine peritonitis, Frey observed the intestinal activity through a celluloid window and found that, dilated and contracted segments responded similarly to stimulation with choline given subcutaneously. In the intestines distended with gas for several hours, Hotz found that, the rhythmic contractions of the segment ceased. The gaseous distension of the loop and not the toxins of peritonitis, Hotz concluded were responsible for the disappearance of intestinal contractions. Distension of the intestine impairs absorption, and the gas in the intestine, which is normally carried away as fast as it is formed, continues to accumulate and a vicious circle ensues (Altarz, Usadel).

B PATHOLOGY

The entire intestine may be dilated in paralytic ileus. The degree of intestinal dilatation may vary considerably. There are usually large collections of both fluid and gas throughout the entire intestine. The bowel wall is very much thinned out and is frequently somewhat dusky in appearance due to the venous stasis occasioned by the dilatation of the bowel and pressure on the mesenteric veins returning from over the surface of the bowel. In peritonitis, the serous surfaces of the visceral peritoneum partake of the characters of the inflamed peritoneum in general, presenting a red dish angry surface with frequently a disappearance of the normal sheen and luster of the intestine. The collection of exudate in the peritoneal cavity may be serous, fibrinous, or fibrinoplastic in character. In cases of paralytic ileus of a reflex nature, no fluid is ordinarily present in the peritoneal cavity and the parietal serous surfaces appear normal. Despite the enormous distension that may be seen in paralytic ileus, perforation and gangrene of the intestine are rare occurrences.

It is not unlikely that the end effects of distension in inhibitive (paralytic) ileus are not unlike those of mechanical obstruction upon the bowel wall. That a sustained intraluminal pressure whether occasioned by a mechanical obstruction or paresis of the bowel wall subjects the bowel wall to the hazards of anoxemia. Inasmuch as peristaltic contractions are not pyramided on the sustained intraluminal pressure in the latter condition the injury to the bowel wall would not be as prominent. Further there have been very few recordings of intraluminal pressure in a dilated paretic bowel. However, it is likely that, the end effects are largely the same in loops of bowel, becoming dilated to the same extent over similar

likelihood of quicker decompression of the distended intestine. When the distension concerns the colon essentially, the tidal irrigation as suggested by Pratt may be helpful. Rectal irrigation in peritonitis is distinctly out of place. Feces and the colonic flexures, moreover, constitute serious obstacles to effectual operation of rectal siphonage. The necessity for enterostomy has been largely done away with by the more effectual and less hazardous practice of gastro duodenal siphonage.

Occasionally, within a few minutes following aspiration of large quantities of gas and fluid from the stomach and upper reaches of the small intestine, a cyanotic and apparently moribund patient may present a wholly changed appearance. In the instance of an old man with a urinary tract infection 7000 cubic centimeters, largely gas, was aspirated in a few minutes with startling immediate results and eventual recovery, in a patient whose status was extremely precarious because of a ruptured spleen the removal of 4500 cubic centimeters of gas and fluid by gastric siphonage revived what appeared to be a dying man. These rather extreme cases attest the significance of the mechanical effects of distension.

The suggestion of Handley that an ileo colostomy be done in instances of paralytic ileus would appear to have no justification. He alleges that an 'ileus duplex' obtains in paralytic obstructions, by which designation he implies that there is simultaneous mechanical obstruction to the small intestine and inhibitory to the colon. No proof has been brought forward to indicate that this is the state of affairs in paralytic ileus. All evidence would point to the contrary, viz. that the small and large bowel participate in the same inhibitory process the extent of which may vary considerably. It would not appear that the operation which Handley has recommended has any place in the treatment of paralytic ileus. Cases which one may with justice call "ileus duplex" or multiple obstructions in the experience of the writer, have been mechanical in nature. The most frequent association has been adhesive obstruction of the small intestine and carcinoma of the colon. When a carcinoma or granulomatous process in the colon ulcerates into the small intestine and establishes an artificial anastomosis obstructive features common to both small and large intestine may be observed. Finsterer, Block and Schlaepfer have reported instances of multiple obstruction.

For protracted inhibitory ileus not due to peritonitis and refractory to treatment by suction spinal anesthesia may prove of value in some instances. It has been demonstrated experimentally, when the sympathetic inhibition to the intestine is released by cutting the splanchnics by splanchnic or spinal anesthesia that evacuation of the intestine may be obtained. Arat, Markowitz and Campbell and Ochsner and his associates have produced chemical peritonitis by the intraperitoneal injection of iodine following which the motility of the intestine for the transport of barium practically ceased. Following the administration of spinal anesthesia intestinal contractions would again function and evacuations were obtained. David and Loring however, found splanchnic anesthesia to be effectual for only brief periods.

A considerable number of clinical papers have accrued to attest the

In those instances of reflex ileus due to renal colic, torsion of the ovum, or the like, subsidence of the primary disorder arrests the progress of the inhibition ileus and the symptoms quickly subside. In paralytic ileus due to peritonitis, however, delirium and coma are usually superimposed on the picture described and the end is often fatal.

Here might be mentioned a type of paralytic or inhibition ileus described by Brunzel (1918) to which he gave the name of "fermentative ileus." His report concerned 2 cases who exhibited signs of intestinal obstruction of a paralytic character following the ingestion of raw beans, and Brizke has since reported several such cases after the eating of oats. Some of these latter have, however, been actual cases of impaction in the bowel.

There are occasions in which differential diagnosis between mechanical spastic and inhibitive (paralytic) ileus may be difficult or impossible to make. The consideration which causes the clinician the greatest concern is whether a strangulating mechanical obstruction may be present. The writer has encountered this dilemma many times, once in a severe post-operative wound infection which gave very few local signs.

DIAGNOSIS

The treatment of paralytic ileus presents two extreme difficulties, (1) to cope successfully with the cause and (2) the treatment of the inactive bowel. In inhibition ileus occasioned by retroperitoneal collections of exudate, the treatment indicated is adequate drainage, and in the presence of hemorrhage, the staunching of the source of blood loss. Following trauma, the ileus though primarily of severe grade, usually responds to conservative measures of treatment. Following torsion of the testis or ovary, the paresis of the intestine usually comes to a standstill after the active process has reached its peak or following proper surgical treatment.

Considerable has been written concerning the value of various conservative measures of treatment. Hot stupes to the abdomen, atropine, pituitary extract, pilocarpine, physostigmine, and choline have all been advocated in the treatment of the distension observed during the course of the ileus. Though enemas may give temporary relief and may permit of the evacuation of some gas, they are usually of no great value and are to be avoided in the presence of intraperitoneal infection. In paralytic ileus accompanying peritonitis, the value of enterostomy has been extolled by a number of authors. Prominent among these are Krogus, Heidenhain, Melchior, Hofmeister, and Kausch. The observation of most surgeons has been that catheter drainage of the intestine in paralytic ileus is one of very limited value because only a short segment on either side of the catheter is evacuated by the tube. Heidenhain and others have recommended employment of multiple enterostomies.

The agent of most value in the treatment of paralytic ileus is the application of suction to an intubing duodenal tube. With the employment of this expedient the stomach and upper jejunum will usually be emptied immediately. Employment of the Miller-Abbott tube has enhanced the

tension, no patient with paralytic ileus has been subjected to operation for its relief. Yet, the more rapid deflation attending surgical relief of a persistent gaseous distension would appear to warrant its occasional employment in those instances which respond slowly or remain refractory to an adequate trial with suction.

Smith (1941) has reported from this clinic two instances, in which plastic masses gave rise to intestinal obstruction. The patients were treated with the Kettering hypertherm unit, suction being employed to control distension. Prior to employment of suction, such patients were operated upon, enterostomy or colostomy being performed usually. A not infrequent sequel was spreading peritonitis with more distension necessitating another operative procedure. The writer once did 3 successive enterostomies for such a patient, she dying ultimately of peritonitis—the peritoneal infection gaining a little more headway with each operative endeavor. Suction has changed all this. A patient who can live for weeks with some distension has a good chance of recovery, if the distension can be dealt with satisfactorily by non-operative means. The Miller Abbott tube with intermittent suction and feeding combined with proper use of the Kettering hypertherm and the sulfonamides affords a number of such patients the opportunity of surviving peritonitis granted that the organism can hold the infection in check.

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value of spinal anesthesia in paralytic ileus Duval has collected 400 cases of obstruction of various sorts from the French literature in which spinal anesthesia has been employed with varying success Wagner was the first, in 1912, to apply the experimental knowledge of the release of splanchnic inhibition in cases of paralytic ileus He introduced paravertebral splanchnic anesthesia in a number of cases and reported eight cases in which there was marked retrogression of the meteorism following its employment Novikov (1910) has suggested and employed right or left lumbar novocaine block in the treatment of inhibitive ileus He finds that its use makes operation unnecessary in patients with ileus, in which the obstruction is not mechanical in origin He finds such novocaine blocks helpful also in instances of spastic ileus Novikov recommends the injection of 50 to 100 cc of a $\frac{1}{4}$ per cent solution of novocaine The investigations of Shumacher (1941) on novocaine toxicity and absorption deserve study by everyone interested in this aspect of the problem

Another agent of value in certain cases in inhibitive ileus is the intravenous injection of hypertonic solution of saline Hotz pointed out the stimulating effect of intravenous injections of saline solution upon intestinal contractions and Hughson and Scarff first directed attention to the clinical value of this drug in increasing the motile power of a parietic intestine One sixth to one third of a gram per kilo body weight may safely be injected Seventy five to one hundred cubic centimeters of a 15 per cent solution of sodium chloride is the usual dose for a person weighing 70 kilos (154 pounds) and is often very effectual

In the main the writer inclines to the passive treatment of inhibitive ileus by suction reserving the employment of active stimulating agents for instances in which such additional therapy is necessary Use of the long balloon tipped tube (Miller-Abbott) is advisable when an intubating duodenal tube fails to relieve the distension Hotz (1909) indicated many years ago that, such loops had not lost their contractility Decompression, however, may be even more difficult than in a mechanical obstruction presenting a similar grade of distension Golden and associates (1940) emphasize that in many instances despite entry of the balloon tipped tube into the duodenum, progress of the tube down the intestine is unusually slow— $\frac{1}{2}$ to 7 days and longer being required occasionally to effect decompression The majority of instances of paralytic ileus can be managed without recourse to drugs such as pituitary extract, prostigmine eserine, or hypertonic intravenous saline solutions Despite the vigorous application of suction to intubating duodenal tubes, as a routine measure in the treatment of established paralytic ileus, an occasional case may be observed in which recourse will have to be had to operation to achieve adequate decompression Instances of paralytic ileus not due to peritonitis not uncommonly respond as favorably to surgical decompression as do instances of mechanical obstruction (Hunt, Bartlett) The segment which has been most greatly and persistently dilated as determined by x ray examinations should be tapped by enterostomy or colostomy as outlined under the caption of operations Over an eleven year interval during which time suction has been widely employed at the University of Minnesota Hospitals in the treatment of dis-

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CHAPTER XXIV

SPASTIC ILEUS

(Dynamic Obstruction)

A PATHOGENESIS

This disease was first described as an entity by J B Murphy in 1896. His description concerned a painter who was taken ill with abdominal cramps of a spasmodic character, vomiting and an inability to move the bowels. The abdomen was greatly distended and all efforts to move the bowels by cathartics and intestinal irrigations proved futile. The patient had previously had attacks of lead colic. At operation Murphy found a loop of small intestine about eight inches in length that was contracted and stiff as a rope of similar size, the intestinal coil being about three-eighths of an inch in diameter (Fig 140). The intestine above it was somewhat dilated and measured two and one half inches in diameter and was distended with gas and fluid feces. The intestine below was empty, soft and pliable. After ten minutes' exposure to the air spasm at the proximal end substantially diminished and the contracted segment began to dilate. After twenty minutes of observation, this contracted coil had expanded about one inch in diameter and was returned to the abdomen.



FIG 140—J B Murphy's case of spastic ileum of the small intestine illustrating the contraction of the bowel (J.A.M.A. 26 15 1896)

Two years later, Heidenhain reported three similar cases and since that time the entity of spastic ileus has become fairly well known. In 1924 Korte reported 28 cases that had come under his observation. Zimmerman has recently collected 157 cases of this type. The majority of cases were in patients in the mid span of life, 3 were under one year. The writer has observed spastic ileus in a patient past 80 years.

Fromme classifies the causes of spastic obstruction as follows:

- (1) External due to injuries
- (2) Factors from within the bowel, such as foreign bodies, worms, ulcers and irritating intestinal content
- (3) Neurasthenia and hysteria
- (4) Unknown

Attention has already been called to the fact that spasm may be an initial step in intussusception and that it may play an important role in gallstone obstruction when the size of the gallstone is not of itself large enough to occlude the lumen of the bowel. Its role in producing obstruction

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cently this manifestation of spastic ileus. The majority of these patients are women who, in the absence of symptoms of obstruction, are readily recognized as neurotics whose chief complaint concerns the bowel. Many have trouble with constipation, others with gas and pain. At times such patients may be subject to diarrhea; many have been repeatedly subjected to operation under the diagnosis of mechanical obstruction of adhesive origin. Some of these patients may present at times, as well, a picture which resembles paralytic ileus. The effect in either event may be the same, viz. dilatation of the entire bowel. Morse (1936) has described observing sudden reversals from hypertonicity to hypotonicity of the colonic musculature and vice versa with the aid of the barium enema. When the patient is afflicted with spastic ileus he has gas pains and *intestinal colic* can be demonstrated, in the other instance he complains only of distension and the abdomen is silent. The writer has thrice observed palpable peristalsis in spastic ileus, the gut being felt through the layers of the abdominal wall—a finding which obtains regularly when acute intestinal obstruction attends stricture of the gut (see Fig. 21).

D DIAGNOSIS

There is no way in which one can wholly be certain that such an obstruction precluding all the clinical features of mechanical occlusion is merely due to spasm without recourse to operation. The antecedent history is frequently helpful. A history of bowel distress over a long period of time is suggestive. The patient whose symptoms of obstruction begin acutely with an attack of renal colic, after injury or intraperitoneal hemorrhage, can usually be correctly identified without much difficulty. Spastic ileus involving the colon may be confused with mechanical obstruction of the colon due to carcinoma. It would appear that the mere administration of a barium enema would serve to differentiate these. Unfortunately, however, such is not always the case. Some of these difficulties have already been described (pages 93 and 105). Could the roentgenologist be as certain of his findings with the barium enema in the presence of great distension as he is when distension is absent, colonic spastic ileus would occasion no trouble in differentiation. The employment of spinal anesthesia is sometimes helpful in that with release of the sympathetic nervous influence to the bowel, spontaneous evacuation ensues (Scott and Morton).



FIG. 141.—Enormous distension of the colon in spastic ileus. This patient had been operated upon many times for adhesive obstruction. The greatest difficulty lies in differentiating the intestinal colic and distension of this condition from that due to an organic obstruction of the pelvic colon.

in the presence of worms in the intestine has already been described (Chap 14) Korte described also spastic ileus concomitant with an attack of renal colic and refers to its occurrence in the presence of uremia. In the course of influenza and other infectious fevers, the occurrence of spastic ileus has several times been noted. Steindl has recently contended that degenerative changes in the medulla oblongata may precipitate intestinal spasm. Occasionally a patient who has been observed through several attacks of spastic ileus of unknown origin will finally present a reasonable cause. The writer has observed this occurrence in two patients one of whom subsequently showed unmistakable evidence of tuberculous peritonitis, the other, of a kidney infection. It is possible that instances of perforation of the colon in new borns (so called meconium ileus) as well as instances of so called simple ulcer of the colon (Barron, Wilkie), are due to spasm of the colon. The role of intestinal spasm in Hirschsprung's disease has been described (chapter XX).

B PATHOLOGY

The appearance of the spastic loop may be that noted by Murphy in lead colic. There may be a single collapsed area of small bowel or there may be numerous such areas. Korte and others have observed instances in which the spasm did not disappear in narcosis, it has also been said to persist even after death for a short time. These occurrences suggest that the intrinsic nerve plexuses in the bowel are largely responsible for the spasm. Segments of the colon or the small intestine may be concerned in the process. In the collapsed segments there may be ring like constrictions. Korte states that four cases of enterospasm under his observation came to necropsy. There was no necrosis of the mucosa and the bowel wall appeared normal. The bowel dilates above the spastic area and exhibits gaseous fluid accumulation. No perforations were noted in fatal instances reported by Korte. Amberger however, reports such an occurrence. It is not unlikely that instances of so called meconium ileus may have their origin in such an agency. Simple ulcer of the colon described by Barron (1928), Wilkie and Barlow (1941) may have its origin through the agency of tension penetration or perforation caused by mechanical spasm in the pelvic colon.

C CLINICAL FEATURES

The clinical picture simulates very closely that of mechanical obstruction. *Intestinal colic* is invariably present. If the obstruction concerns the small intestine, nausea and vomiting are the rule. In instances where the obstructive element has long been present, coils of bowel may be seen and felt through the abdominal wall, lending the impression that a stricture of the bowel is present. The writer has twice encountered this occurrence in the small intestine. In one of these the distension stopped abruptly at the junction with the cecum—an occurrence which would suggest that the neuromuscular mechanism of the ileocecal sphincter was probably at fault. In the experience of the writer the most frequently observed type of spastic ileus concerns the colon (Fig 141). The writer described several such cases in 1931. Colp (1941) has emphasized re-

measures or by operation when necessary, they are subject to frequent recurrences. The writer has observed several patients who have had multiple operations for obstruction, in whom the items of a low basal metabolic rate, achlorhydria and vomiting without much pain suggest a neurotic state. The surgeon must be wary not to start such patients on a course of multiple operations. Some of these patients probably have a condition akin to that of true megacolon and it is not unlikely that relief may be obtained for some of them by the more adequate sympathectomy of Royle or Adson. Antispasmodics such as atropin and amyl nitrate are to be tried, but in the main, have not proved very effectual. Heiman and Cohen and Cowie are enthusiastic over the value of atropin in the relief of enterospasm of children. Cowie states that he has given as much as 1/30 grain (2 mg) of atropin sulphate to obtain relief. Recently it has been suggested that benzedrine may effectively allay intestinal spasm (Myerson and Riton), Desiccated thyroid and Vitamin B₁ are often helpful. (See discussion on page 355 also.)

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E TREATMENT

In those instances in which distension is great, resort must be had to operation. Fatal instances have been reported owing to failure to decompress the distended bowel (Amberger, Korte, Steigmann and Singer). In instances where the diagnosis can be made and distension is not threatening, operation is of no avail. Such cases will usually respond favorably to conservative treatment with suction applied to an intubing duodenal tube and hot applications to the abdomen. Use of the Miller-Abbott tube is helpful to achieve decompression and to permit feeding, as long as the spastic element continues. Such a favorable termination is almost invariable in the acute cases of spastic ileus accompanying injury or infection. Some of these have distension of both the small intestine and colon. All that operation has to offer a patient with spastic obstruction is relief from the distension. Spinal anesthesia sometimes succeeds in securing a spontaneous evacuation in instances of colonic spastic ileus. On one occasion, the writer inserted a sigmoidoscope into the lower bowel for a distance of 20 centimeters and then inverted the patient in the hope that the gas would be released from the greatly distended colon—but without success.

When spastic ileus of the small intestine demands operation, enterostomy should be done, for the colonic case colostomy as described on page 199 should be done. During convalescence after decompression had been achieved by colostomy in a patient with spastic ileus, whose colon was enormously distended, the writer subsequently did the sympathetic neurectomy of Rankin and Learmonth, but without improving the patient's condition. The more complete sympathectomy of Royle or Adson might have been more successful. Flothow and others report good results in some patients with obturate constipation who present some similar features. Scott's suggestion of ascertaining whether spinal anesthesia will afford relief before sympathectomy is done, is a good one. The writer has, however, noted in mechanical obstructions of the small bowel that the diameter of the obstructed coils is also diminished by spinal anesthesia. X-ray films taken immediately before and after the administration of spinal anesthesia in mechanical obstructions of the small bowel, usually reveal a diminution of calibre on the second film.

For this patient, Miss R., University Hospital #55787, aged 23, referred to above for whom the partial sympathetic neurectomy was performed, I subsequently divided the terminal ileum (Dec. 8, 1930), bringing the distal end as a safety vent to the skin, the proximal end being anastomosed end to side to the transverse colon. It was my impression that a catheter could be passed during obstructive attacks into the cecum to relieve distension—an idea which Sprack (1932) put to good use in suggesting employment of the cecum and ascending colon as a blind pouch in patients with a permanent colostomy. Another surgeon did not think well of my idea and closed the safety vent which I had made in the patient described above with recurrent spastic ileus of the colon.

The most unfortunate thing about these patients is that, whereas the acute attack may be dealt with satisfactorily, either by conservative

measures or by operation when necessary, they are subject to frequent recurrences. The writer has observed several patients who have had multiple operations for obstruction in whom the items of a low basal metabolic rate, achlorhydria and vomiting without much pain suggest a neurotic state. The surgeon must be wary not to start such patients on a course of multiple operations. Some of these patients probably have a condition akin to that of true megacolon and it is not unlikely that relief may be obtained for some of them by the more adequate sympathectomy of Royle or Adson. Antispasmodics such as atropin and amyl nitrate are to be tried, but in the main, have not proved very effectual. Heiman and Cohen and Cowie are enthusiastic over the value of atropin in the relief of enterospasm of children. Cowie states that he has given as much as 1/30 grain (2 mg) of atropin sulphate to obtain relief. Recently it has been suggested that benzedrine may effectively allay intestinal spasm (Myerson and Ritov). Deviated thyroid and Vitamin B, are often helpful. (See discussion on page 355 also.)

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CHAPTER XXV

INTESTINAL OBSTRUCTION DUE TO VASCULAR CAUSES, MESENTRIC THROMBOSIS AND EMBOLISM

A PATHOGENESIS

IN 1913 Trotter reported seven new cases of mesenteric thrombosis and embolism and collected in monographic form a total of 360 cases from the literature. He states that arterial occlusion contributed 60 per cent of the total and thrombosis of the mesenteric veins the remaining 40 per cent. In a few smaller series, venous thrombosis has been observed to occur more frequently than thrombosis and embolism of the arteries.

The superior mesenteric artery is more frequently concerned in embolism than is the inferior, partially because of its earlier exit from the aorta but largely because of its more direct continuation from the abdominal aorta. Embolism of the inferior mesenteric artery may obtain and infarction of the bowel fail to occur, significant of the freer anastomosis which occurs between the end vessels of the systemic arteries and the inferior mesenteric branches.

Vegetations on the valves of the left side of the heart are the usual etiologic agents in embolism of the mesenteric arteries. Ginsberg observed embolism to occur 85 times in 250 cases of endocarditis and the superior mesenteric artery was involved in three instances. Sperling, out of 300 cases of endocarditis found embolism in 84 in some organ, including five with embolism in the liver and intestine. Embolism of both mesenteric arteries is a very rare condition, Trotter refers to three such cases.

Embolism of the mesenteric arteries is more frequent than thrombosis of the arteries. Of 187 cases of mesenteric arterial occlusions referred to by Trotter embolism was responsible for 128. In a recent review of 36 postmortem cases of mesenteric vascular occlusion, Larson found arterial thrombosis more frequent than arterial embolism.

Mesenteric venous thrombosis is usually associated with infection in organs or viscera that are tributaries to the portal vein. Appendicitis, portal infections, and strangulation of external hernias are frequent precursors of the occurrence.

Thrombosis or embolism of the mesenteric vessels very rarely affect children. Adults between the ages of 30 and 70 are more likely to be attacked. In Trotter's series males were affected more often—62 per cent as compared to 38 per cent for women.

Occasionally following crushing injuries as when an automobile runs over the abdomen, a tear in the mesentery gives rise to a hematoma which deprives the intestine of its source of blood supply (Cave). Most of these are, however, associated with injuries or tears in the bowel itself. Inadvertent ligation of the midcolic artery in gastric resection has caused gangrene of the transverse colon.

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diarrhea is more frequently observed Shock is generally manifest and the pulse is frequently rapid and irregular In mesenteric thrombosis, the explanation of the shock is apparent in the blood loss occasioned by an extensive venous infarction The temperature is normal or subnormal but occasionally there is fever even at an early stage Distension of the abdomen is progressive though not extreme An abdominal tumor was observed in about 5.6 per cent of the cases of intestinal infarction reported by Trotter Meyer reported the occurrence of melena in 14 per cent of 92 cases of mesenteric vascular occlusion Visible peristalsis was noted in only 4 out of 360 cases collected by Trotter Intestinal noises may be heard on auscultation of the abdomen, but *intestinal colic* is rarely a prominent feature of the acute occlusion Distension of both small and large bowel are usual on a roentgenogram Not uncommonly, the pain which is frequently agonizing in the beginning may show temporary

TABLE XLIV.—SITE OF MESENTERIC VASCULAR OCCLUSION IN SIXTY CASES
(WILLIAMS & PEMBERTON) JOUR. A.M.A. 111 21 24 JULY 2 1938

Type of Occlusion and Vessels Occluded	Cases
Arterial occlusion	10
Superior mesenteric	18
Combined superior and inferior mesenteric	1
Venous occlusion	27
Superior mesenteric	25
Inferior mesenteric	1
Combined superior and inferior mesenteric	1
Combined arterial and venous occlusion	14

diminution of intensity though the other symptoms continue usually unabated until death The infarction of a portion of the intestine is frequently complicated by peritonitis and its sequelae Distension may be absent altogether

D DIFFERENTIAL DIAGNOSIS

Mesenteric thrombosis and embolism are rarely recognized preoperatively A correct preoperative diagnosis was made in only 13 of the 360 cases collected by Trotter My associate Dr Lyle Hay, diagnosed, preoperatively, the presence of mesenteric thrombosis in a patient of 75 Mrs. H. H. University Hospital #713329, and excised successfully a large portion of the small intestine by the closed method Intussusception frequently gives symptoms of a similar sort, but the majority of patients suffering from this disease are young, whereas in infarction, the majority have attained middle life The presence of an abdominal tumor is frequent in intussusception and rare in vascular occlusion Intermittent colicky attacks of pain characterize intussusception, whereas in vascular occlusion the pain is more continuous in character

Previous existence of a probable source for an embolus or adequate cause of mesenteric venous thrombosis should be present before the preoperative diagnosis of vascular occlusion can be entertained Acute pancreatitis or subacute perforation of a viscus that gives rise to signs of peritoneal irritation may lead to confusion The important thing to recognize is that a serious surgical lesion is present that demands opening of the abdomen

B PATHOLOGY

Serious damage to the intestine takes place in a large majority of cases after closure of any but a small branch of the superior mesenteric artery. Closure of the inferior mesenteric artery is not always followed by intestinal infarction. Out of 60 cases showing embolism of the trunk of the superior mesenteric artery, hemorrhagic infarction followed in 45 cases. Edema, discoloration, gangrene, and perforation are the sequence of events unless the infarcted segment is excised. Distension of the in-

TABLE VIII.—THE SOURCE OF THE MESPENTERIC VASCULAR OCCLUSION (WHITAKER & PEMBERTON) JOUR. A.M.A. 111 21 24 JULY 1938

Source or Cause	Artery	Vein	Combined Artery and Vein	Total
Cardiac disease	9	1	5	15
Splenectomy for splenic anemia		1		1
Arteriosclerosis	5	1	2	8
Hepatic disease		6	1	7
Acute abdominal infections		6	1	7
Postoperative abdominal operation	3		2	5
Unknown	1	3		4
Other cases	1	2	3	6
Total	19	27	14	60

involved segment with the accumulation of bloody fluid in the peritoneal cavity as well as within the segment is the rule. The demarcation of the involved intestine from the normal is usually sharp, though in some instances the healthy and diseased intestines are poorly defined.

When obliteration of the mesenteric arteries occurs slowly, intestinal infarction may not result. Chiene has placed on record the instance of a female aged 65 years whose body was dissected in the anatomical laboratories at Edinburgh. The abdominal aorta was completely occluded by an aneurysm that extended as far down as the bifurcation. The branches of the mesenteric arteries were filled by injection through the superior hemorrhoidal, which artery was as large as the femoral.

C CLINICAL FEATURES

It is an interesting fact that many cases of mesenteric vascular occlusion run a fairly mild course, more than a week elapsing frequently before the existence of a serious lesion is suspected. Jackson, Porter, and Quinby found out of 121 cases reported by them in 1904, that the percentage of cases running a course of more than 8 days was about the same as those running a course of less than 8 days. The vascular occlusion in these relatively long cases is probably incomplete and progresses slowly until the bowel finally becomes non-viable. Trotter emphasizes the fact that only a small percentage exhibit prominently the phenomena of mechanical obstruction of the bowel. Distension may be absent.

The usual manifestations of the disease are the sudden onset of severe acute abdominal pain, vomiting and diarrhea. The stools and vomitus occasionally contain blood, constipation may be a prominent feature but

diarrhea is more frequently observed. Shock is generally manifest and the pulse is frequently rapid and irregular. In mesenteric thrombosis, the explanation of the shock is apparent in the blood loss occasioned by an extensive venous infarction. The temperature is normal or subnormal but occasionally there is fever even at an early stage. Distension of the abdomen is progressive though not extreme. An abdominal tumor was observed in about 15 per cent of the cases of intestinal infarction reported by Trotter. Meyer reported the occurrence of melena in 14 per cent of 92 cases of mesenteric vascular occlusion. Visible peristalsis was noted in only 4 out of 360 cases collected by Trotter. Intestinal noises may be heard on auscultation of the abdomen, but *intestinal colic* is rarely a prominent feature of the acute occlusion. Distension of both small and large bowel are usual on a roentgenogram. Not uncommonly the pain which is frequently agonizing in the beginning may show temporary

TABLE XIV.—SITE OF MESENTERIC VASCULAR OCCLUSION IN SIXTY CASES
(WILTAKER & PEMBERTON) JOUR. A. M. A. 111:21,24 JULY 2, 1938

Type of Occlusion and Vessels Occluded	Cases
Arterial occlusion	19
Superior mesenteric	18
Combined superior and inferior mesenteric	1
Venous occlusion	27
Superior mesenteric	25
Inferior mesenteric	1
Combined superior and inferior mesenteric	1
Combined arterial and venous occlusion	14

diminution of intensity, though the other symptoms continue usually unabated until death. The infarction of a portion of the intestine is frequently complicated by peritonitis and its sequelae. Distension may be absent altogether.

D. DIFFERENTIAL DIAGNOSIS

Mesenteric thrombosis and embolism are rarely recognized preoperatively. A correct preoperative diagnosis was made in only 13 of the 360 cases collected by Trotter. My associate Dr. Lyle Hay diagnosed preoperatively the presence of mesenteric thrombosis in a patient of 75, Mrs. H. H., University Hospital #713329 and excised successfully a large portion of the small intestine by the closed method. Intussusception frequently gives symptoms of a similar sort but the majority of patients suffering from this disease are young whereas in infarction the majority have attained middle life. The presence of an abdominal tumor is frequent in intussusception and rare in vascular occlusion. Intermittent colicky attacks of pain characterize intussusception, whereas in vascular occlusion the pain is more continuous in character.

Previous existence of a probable source for an embolus or adequate cause of mesenteric venous thrombosis should be present before the preoperative diagnosis of vascular occlusion can be entertained. Acute pancreatitis or subacute perforation of a viscus that gives rise to signs of peritoneal irritation may lead to confusion. The important thing to recognize is that a serious surgical lesion is present that demands opening of the abdomen.

I TRIATMENT

Early operation and excision of the involved segment of the intestine is indicated. There are a number of reports in the literature of instances in which the abdomen was merely opened and the entire small intestine found to be cyanosed—the patients having recovered without further operative procedure. In such instances undoubtedly the vascular occlusion was incomplete and recovery ensued. Ochsner states that he has observed this occurrence in alcoholism.

Deaver, Jopson, and Laws have each reported instances of this character, and Klein refers to 8 other patients reported in the literature where spontaneous cure obtained without the reliable corroborative confirmation supplied by exploratory laparotomy.

The first successful operation for intestinal infarction was done by Elliot in 1895. The mortality of operation is admittedly high because of the nature of the disease. With early recognition in cases in which only a portion of the intestine is involved, a marked reduction in the present high mortality of the disease should obtain. In the 47 cases subjected to operation quoted by Jackson, Porter and Quinby, there were 4 recoveries. Klein states that up to 1921, 24 cases had been dealt with successfully by operation. In 1931, Meyer stated that 92 recorded operations for mesenteric vascular occlusion were to be found in the literature. In this group alone, there were 39 recoveries. Douglas reported 11 cases of mesenteric vascular occlusion from the records of St. Luke's Hospital in New York. Four of the group recovered.

Intestine damaged beyond recovery of viability must be excised. Primary excision followed by a lateral anastomosis is the operation of choice when feasible. In dealing with a very ill patient, small intestine and later reestab-



FIG 142.—Exteriorization in continuity of bowel of questioned viability. This patient aged 68 presented findings of intestinal colic with rebound tenderness suggesting the presence of a strangulating obstruction. At operation a single coil of mid small intestine was found to be discolored. It was quite free and exhibited no effects of pressure by an adhesions band from which it might possibly have escaped. A local segmental arterial or venous thrombosis therefore would appear to have been responsible for discoloration of this coil. Because of its doubtful viability it was exteriorized seven days later when its viability was certain it was returned to the peritoneal cavity and the patient has remained well. Primary resection is probably a better operation. Should the bowel prove non viable the procedure illustrated here would result in complete external fistula—an undesirable complication.

Elliot exteriorized the gangrenous

lished the continuity of the bowel. After the method of McKinnon and Wilkie, the intestinal discharges from the proximal loop may be collected and poured into the distal loop. If the bowel is doubtfully viable, it may be exteriorized (Fig. 142). The closed anastomosis, in practiced hands, can be made with little risk, however, and is to be preferred, usually, to exteriorization or the establishment of an external fistula.

How Much Small Intestine May Be Excised Safely?

A vital consideration in the proper conduct of extensive infarction of the small intestine is how much bowel may safely be excised compatible with subsequent good health.

Flint has studied this problem experimentally and concluded that as

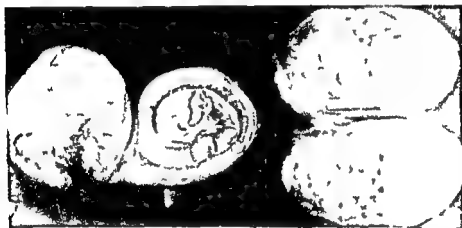


FIG. 143.—Large fibromyxosarcoma necessitating excision of a long segment of small intestine. The tumor involved the superior mesenteric artery just beyond the branches of the first few jejunal and the right colic artery. 360 cms. of small intestine were excised. Four years previously an extensive resection (75%) of the stomach was done for carcinoma.

much as 50 per cent of the total small intestine of the dog may be removed without persistent untoward effects. At first, the animals suffer from a severe diarrhea, ravenous thirst, and appetite. There is usually severe weight loss which is only gradually recovered from and the dogs usually remain extremely sensitive to unfavorable conditions of diet and living. Such animals should be maintained on a high carbohydrate and poor fat diet. Protein is not utilized as fully as normally but in the presence of a diet rich in fat dogs deprived of half or more of their small intestine exhibit marked increase of nitrogen excretion in the feces. Resections of 75 per cent and even more of the total small intestine may be survived, but such animals are unlikely to show a true recovery. Only infrequently is the normal weight and a good compensatory assimilative process attained.

According to Flint, a compensatory process consisting in hypertrophy

Moynihan has collected 51 resections of the small intestine all than 192 centimeters in length, all of which patients with a single resection made a successful operative recovery.* Many died subsequently, however, of a marantic condition. Watson was able to find 73 cases of resection of more than 200 centimeters of small intestine reported in literature, and Brenzler has recently added a case of his own and other scattered reports to Watson's series.

Treves measured the small intestine in 100 bodies and found the average length in the adult male to be 22 feet, 5 inches (683 centimeters) and in the adult female 23 feet, 4 inches (706 centimeters). The smallest small intestine was 15 feet, 6 inches (471 centimeters), the longest, 31 feet, 11 inches (960 centimeters)—a difference of more than 16 feet (489 centimeters). Feldman states Merola found only 80 centimeters of small intestine in a man of 60.

The most extensive resection of small intestine recorded to date was performed by Jerrault, who excised 19 feet (579 centimeters) of small intestine for gangrene caused by an embolus of the superior mesenteric artery. The patient was subsequently operated upon by Washburn for intestinal obstruction due to adhesions, at which time 10 feet (305 centimeters) of small intestine remained. In the joint publication made by the two authors, the patient was reported to complain of periodic spasmodic diarrhea but at the last examination 3 years after the first operation the patient weighed 5 pounds more than before the initial operation.

A patient operated upon by Doersler appears to have survived on a remaining portion of small intestine so short that Doersler is prompted to ask whether man may live without the small intestine. He resected 1 foot 8 inches (560 centimeters) of small intestine for a volvulus of the terminal small bowel of 30 hours' standing. Twelve centimeters remained below the duodeno-jejunal juncture and 20 centimeters above the cecum. Six and a half years later, when Doersler made his report, the patient was in good health and partook of food only at regular mealtime and in ordinary amounts, his bowels moved normally twice a day. For some time immediately following the operation, however, the patient was distressed by bowel movements every four hours and was considerably troubled by gas, he had then found it necessary to eat something every two hours.

Denk has reported an instance in which Brenner excised 18 feet (549 centimeters) of small intestine in the operative cure of a strangulated hernia. Two and a half months as well as a year and a half after operation, absorption experiments demonstrated a mild disturbance in the

* Unsuccessful cases are reported rarely.

sorption of fat The patient maintained his weight of 48 kilos, however, and only complained of a moderate diarrhea Shortly after the second observation, the patient appeared to decline and lose in strength and weight and developed real hunger despite the liberal ingestion of food Death occurred two and a half years after operation At that time the weight was only 26.5 kilos At postmortem 3 feet, 5 inches (106 centimeters) of small intestine remained In a man aged 68, Mr S O, University Hospital, #649203, the writer excised 360 centimeters of small intestine in the removal of a large fibromyxosarcoma which involved the superior mesenteric artery just beyond the first jejunal and the right colic artery (Fig 143) All of the small intestine except about 150 centimeters was removed Four years previously, the writer had performed subtotal gastric resection for carcinoma of the stomach The patient died of coronary thrombosis two months after dismissal from the hospital In another patient, the writer excised 180 centimeters of small intestine for multiple lymphosarcomas, constituting about two thirds of the entire small intestine (Fig 89, p 295)

Reginald Jackson records the excision of 4 feet, 8 inches (142 centimeters) of the small intestine in a two year old boy for acute intestinal obstruction due to a strangulation of a portion of the intestine through a congenital opening in the root of the mesentery During the year immediately following the boy's life was often despaired of because of the frequent stools (seven or eight a day), at the time of the report, seven years after operation, the boy was well except for occasional attacks of diarrhea

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AUTHOR INDEX

(**Bold face numerals** refer to the pages in text upon which author's name appears)

- Abbott A W 416
 Abbott W O 161 162 164 175 176
 see Johnston 251 402 405 see Miller
 T C 416 441
 Abt I 3 7 see Cubbins
 Ackman F D 330
 von Ackmatowicz L 392
 Adam A 378 see Chaoul and Sauerbruch
 Adam I 311
 Adams G F 50 100 136
 Adams J F 393 see Eastin
 Adam J D 345
 Adamson E W 327 332 see Hild
 Adahok E P 236 see Schmidt E R
 Curran and Hilde
 Adolph E F 8 9 60 134
 Adson A W 334 335 336 337 338 see
 Judd and Thompson H L 448 449
 see Brown G E
 Agrot G 372 378 392
 Aird I 43 55 56 58 60 211
 Aitkin R S 128
 Akerlund A 377
 Alberta M 410 416
 Alexander E G 364
 Allen A W 123 128 see Benedict
 Alvarez W C 94 436 441
 Amberger J 446 448 449
 Amusat 3 44 60
 Anders E 274 277 287
 Anderson W 355
 Andrews W 372 379
 Andries R C 46 69 see McLean A
 Anschutz W 30 60 298 301 313 317
 Anpach D M 214
 Antonic R F 40 65 see Lawson
 Ara H 439 441
 Archer W 326 327 331 see Peterson
 Armitage G 376 380
 Armour J C 10 65 see Brown Dunlap
 Mitchell Searls and Stewart
 Armstrong W D 132 137 see Paine
 Arnold L 50 71 see Shuger
 Arntzen L 413 416 see Helsted
 Achoff L 377 381
 Acher P W 433 see Karelitz
 Ashhurst A P C 282 287 373 379 see
 Bramlett
 Askupmark E 337
 Atkinson W 365 see Wakeley 375 381
 see Mason
 Auberge A 262 273 see Pehu
 Averbach B F 336 374 379
 Ayres K D 10 33 69 see Gatch and
 Truier
 Babey A M 128 see Hurst
 Bailey H 91 407 416
 Bailey P 369 377
 Bainbridge F 50 60
 Baldwin H E 399 416 see Bettman R
 B
 Balfour D C 91 129 see Eusterman
 Balfour F M 261 271
 Ball C F 379
 Banks B M 67 137 see Fine Sears and
 Hermanon
 Barbour H G 244 251 see Hamilton
 W F
 Barden R P 235 207 see McCray and
 Radin
 Barenberg L H 336 337 see Greene
 and Greenspan
 Baren J A 14 67 see Falconer and
 Osterberg 259 see Schlicke 299 310
 330 see Benson 399 419 see Chris-
 tianon 450 see Wakefield and Mayo
 C W
 Barker A 416
 Barlow D 446 449
 Barlow T 406 416 see Mattershead
 Barnard H D 316 328
 Barrington Ward L E 333 338 414
 415 416
 Barron M E 446 449
 Barth E E 432 see Becker Windle and
 Schulz
 Bartle H J 333
 Bartlett R M 136 see Coller Maddock
 Bingham and Pedersen S
 Bartlett W Jr 440 441
 Barden M 345 392
 Bats J A 380
 Bats J M 271
 Bauer R 210 410 416
 Baumler D 389 392
 Bauman L 68 see Ingwalden and
 Whipple A O
 Baux 278 287
 Bayless W N 65 136 437 441 see
 Starling
 Beard J W 137 16 see Blalock and
 Thuss
 Beaver D C 310 see Dixon C F

- Beaver M C 129 see Higgins
 Becher F 59 G.
 Beck W C 212 see Kouchy
 Becker R F 265 271 426 432 see
 Windle Birth and Schulz
 Beer T 323
 Bell H C 431 see Mohl
 Bell S H 311 see Harris
 Beller A J 361 see Colp
 Bellis C J 27 41 42 44 59 G. see
 Larson and Stevens see Wange-
 teen 242 244 252
 Bender K W 392
 Benedict F H 18 69 see McIver and
 Redfield 128 see Allen
 Benjamin A I 416
 Benson K W 330 see Bergen
 Berg 313
 Berg B V 44 69 see Meloney and
 Jobling
 Bergh G 119 128 see Bowers W F
 and Wangersteen
 Bergmann F 126 129
 Berman J H 267
 Bernheim B M 38 60 72 see Whipple
 G H and Firor
 Berry 334 338
 Besser F L 64 65
 Bewick W F 69 see Jenkin H I
 Bettman A R 324 330 see Blum 399
 416 see Baldwin 431 433 see Blum
 Bettman R B 330 see Blum 377 see
 He 433 see Blum
 de Beule 361
 Bevan A D 284 287
 Biegan I F 449
 Bigger I A 220 225 235 see Horley
 Biller S H 395 see Pines and Rabino-
 vitch
 Bingham D I C 136 see Collier Bart-
 lett and Maddock
 Birgfield F 269 271
 Bigard J D 14 63 see McIntyre and
 Oheroff W
 Bissell F S 177 see McClendon Lowe
 Meyer and Medes
 Black W T 364
 Blalock A 132 136 see Beard and
 Thuss 253 see Minot
 Bland-Sutton J 262 271
 Bloch O 313
 Block W 439 444
 Blodgett J B 364 433 see Gro R E
 Bloodgood J C 345
 Blum D M 330 433 see Bettman R B
 Bobier P 392
 Bodenhammer W 278 286 287
 Bodenheimer M 364 see Casten
 Bohrer J V 129
 Boland F A 258
 Bollman J I 11 see Walters and Kil-
 gore 72 157 178
 Bonney V 193 213
 Bonomini H 401 416
 Borbe 380
 Borman C V 71 see Dvorak and
 Wangersteen 96 see Coehl Lynch
 and Wangersteen 318 328 see Rigler
 Borrutau H 45 66 see Braun
 Bot T C 216 293 310
 Bottin J W 56 66
 de Boy R 313
 Bower J O 362 364
 Bowers W F 119 128 see Bergh and
 Wangersteen 271 280 287 see Cook
 M M
 Boyce F F 258 see McFetridge
 Boyd I 396 410
 Boyden F A 93 see Rigler 328
 Boys F 353 357 see Lehman
 Brady I 457
 von Brauenig K 392
 Brimlett W 373 379 see Alhurst
 Brandberg R 32 66
 Braun W 45 66 211 255 258 259 291
 310 311 311 364 383 384 392 see
 Borrutau and Wortmann
 Brehm O 384 392
 Brennan R F 327 332 see Bullowa
 Brennehan J 277 287 333 338
 Brenner I C 280 287
 Brenzier A G 456 458
 Brill S 255 258
 Britze F W 323 330 438 441
 Brockman R St I 59 66
 Brown G F 51 59 66 see Eutermin
 Hartman and Rowntree 449 see
 Adson
 Brown H P 411 416 441
 Brown K P 355
 Brown I 310 see Simpson H
 Brown P W 331
 Brown R 415 416 441
 Brown R O 73 see Williamson C S
 Brown S 255 259 see Dennis C
 Brown W E 188 212 see Graham
 R R
 Bruce H A 376 381 see Ross J W
 Brunn H 115 see Levitt 311 see Harris
 Brunner C 310
 Brunzel H F 438 441
 Bryant J 347 355
 Buchanan J J 431 433
 Buchbinder J R 357
 Buckley J P 400 416
 Buemann W H 348 355
 Bue L A 299 see Rankin and Bergen
 Buirge R E 32 66

- Bull W T 358 361 see Coley
 Bullock J C M 327 339 see Brennan
 R F
 Bundschuh F 399
 Burgess A H 299 313
 Burget G F 28 38 39 40 66 see
 Martzloff Suckow and Thornton
 Burrows H 416
 Burt C W 311 see Erdmann
- Calder 271
 Callender C I 379 see Ruck and Nemir
 Cameron A J 215
 Cameron J A M 416 see McFarlane
 Campbell F H 91
 Campbell O J 235
 Campbell W R 439 413 see Markowitz
 Cannon P R 264 271 see Halpern
 Cannon W H 238 252 411
 Cantin A Y 331 see Kirk
 Capelle W 411 416
 Carling F R 264 267 271
 Carl on A J 441 see Smith E A and
 Gibbins
 Carl on H A 32 46 66 67 91 241
 252 see Dvorak Lynch Wangen-
 teen
 Carl on H E 91 see Orr T G
 de Carrera C 243 see Vallois Gubal
 and Chaptal
 Case J T 96 295 319 374 377 see
 Upson
 Ca ten D 364 see Bodenheimer
 Cattell R B 364
 Cautley F 271
 Cave H W 287 312 341 451 457
 Chaffin L 397 416 see Ma on and
 Slemons
 Chalfant S A 386 393 396
 Chamberlin G W 399 416
 Chandler L R 236 287
 Chaoul H 38 see Sauerbruch and
 Adam A
 Chase A F 44 69 see MacNeal N J
 Chauncey L R 227 235
 Cheever D 216 415 419 see Oughter-
 son 441
 Chenut A 58 66
 Chiene J 452 457
 Christian or H W 449 see Bergen
 Christopher F 399 416 449
 Chumley C L 312 314 see Rankin
 Chumley J 40 69 see Lawson
 Chunn E 10 44 72 see Wangensteen
 Clairmont P 45 66 see Ranzi E
 Clark III E 313 see Erdmann
 Clavel C 450 see Tixier
 Clifton H C 309 397 416 see Landry
 B B
- Cline J W 13 69 see McIver
 Clogg H 271 282 287
 Close H C 417
 Clulbe C I B 396 403 409 412 414
 415 417
 Cobb D H 431 433
 Codman F A 255 259 388 393
 Coffen T H 310
 Coffey R C 311
 Cohen I 97 see Solis and Levine S
 Cohen M 415 417
 Cohen P 449 450 see Heiman
 Cohn F J 246
 Cole W H 59 67 267 271
 Coleman C C 293 see Horsley 311
 Coleman G H 93 see Copps
 Coley W E 358 361 433 see Fortune
 Coller F A 14 66 129 see Farris J M
 136 172 173 185 213 240 243 252
 see Bartlett Bingham Maddock and
 Pedersen
 Collins E N 292 310 see Jones T E
 Colmers F 449
 Colp R 59 66 213 see Louria 364 see
 Beller 446 449
 Condon A P 91
 Conroe B I 91
 Cook M M 271 280 287
 Cooke H H 294 312
 Coombs J N 115
 Cooper H S F 64 66
 Cope Z 93 91
 Copenhaver N H 377 379 381
 Copps J A 93 see Coleman G H
 Corbin F G 333 338
 Cordes I 272
 Corkhill T F and H H 268 272
 Cornell N W 255 259
 Corner E M 417
 Corcoran J A 397 406 417 see
 Eliot E
 Cort W W 331 see Otto and Spindler
 Courvoisier L G 316 323
 Cowell F M 272
 Cowie D M 449
 Crandall L A 178 see Roberts G M
 Crle G W 433 see Portmann
 Cripps H 280 282 285 287
 Crohn B B 310 see Ginzburg Oppen-
 heimer and Lunich 331 see Otto
 and Spindler
 Cross D G T 441
 Crou e H 345
 Crumpacker L K 431 see Waugh and
 Herrell
 Cubbins W R 355 357 377 see Abt
 Curling T P 275
 Curreri A R 236 see Schmidt Hidde-
 and Adahelk

- Curschman I 384 393
 Cu ling H 120 129 see Livingood
 Cutler F C 14 60 see Fignon M
 Cutler C D 380 393
 Cutting H A 27 66 113 see Och ner
 and Gage
 Dack G M 57 68 see Dragstedt I R
 Haerem and Wil on
 David V C 50 see McGill 277 287
 333 337 338 412 see Ioring M
 Davidson S C 338 see Fowler and Mel
 lon
 Davis D I 262 263 272 see Poynter
 C W M
 Davis D M 44 66 see Stone
 Davis H A 136
 Davis M B 323 330
 Day R 419
 Deaver J B 255 259 347 348 355 361
 see Ross G G 393 see Magoun 457
 458 see Ross G G
 DeCowan F I 240 252 see Hardin
 Delbet M P 393
 Delprat G D 268 273 see Weeks
 Demel R 435 442
 Demidova P N 100 115
 Demmer F 268 272
 Dennis C 207 230 234 235 255 257
 259 302 389 393 397 410 417 see
 Brown ■
 Dennis F S 126 129
 Denny F S 261 272 see Sloan I H
 Desjardins A 372 373 379
 Deutermann J I 432 see Dixon
 Dewis J W 290 309 378 see Miller
 R H
 Dixon C F 129 see Rivford 176 259
 see Borgen and Schliche 310 see
 Beaver D C 432 see Deutermann
 Dock W 442 see Hartman H
 Doerfler H 391 393 456 458
 Donovan R J 268 272 378 426 432
 see McIntosh
 Doss A H 156 176
 Dott N M 386 389 393 421 423 425
 426 432
 Doub H ■ 312 see Jones H C
 Douglas J 454 457
 Dowd C N 213 355 409 417
 Dowdle E 379
 Downes T M 213 see Lee W E
 Dragstedt C A 8 26 33 44 66 see
 also L R 231 235 see Lang and
 Millet
 Dragstedt I R II 59 66 67 see Ellis
 Montgomery and Matthews 68 see
 Haerem and Dack 426 432 see Hay
 mond
 Drinker C H 50 67 see Field M E
 Drogenmueller F H 69 177 see Ivy and
 Meyer J I
 Drummond H 417
 Duckett J W 433
 Duff ■ I 130 see Rich
 Dunlap D M ■ see Armour Brown
 T C Mitchell Searls and Stewart
 Duval R 364 440 412
 Dvorak H J 67 71 191 see Carl-on
 H A Lynch Wangenstein Erick
 son T C and Smith V D
 Dwight T 340 345
 Fastin F R 393 see Adams J I
 Eaton F G 252 see Jones C M
 Edington G H 285 287
 Edmunds A 91
 Edwards C R 375 390
 Eggers C 432
 Finhorn M 160 175 176
 Einendrath D N 433 435 412
 Fieber H B 216 293 309 457
 v Fieberberg A 303 393
 Ewing E H 310 361
 Flason F L 345 see Erb
 Eliot E Jr 417 see Corcoran
 Elliot J W 454 457
 Elliott A H 330
 Fillingier A 70 see Prutz
 Ellis J C 11 67 see Dragstedt I R
 Elman R 59 67 see Cole W H 157
 176 see McCaughan 197 204 211
 215 see Hartmann H R 246 252
 409 417 see Goldman 432 see Hart
 man
 Emery F E 325 331 see Herrick
 Enderlen E 33 45 67 see Hess 120
 129 see Sauerbruch
 Eneboe J B 366 378 see Rigler
 Engstad J E 372 379 412
 Erb I H 264 272 345 see Ellis on
 Erdmann J F 311 see Burt 313 see
 Clark H E
 Erkes F 377 381
 Ernst N P 261 272
 Estes W L 206 214 351 355 see Holm
 Eustermann G D 51 59 66 see Brown
 G E Hartman H R and Rown
 tree 91 99 129 see Balfour
 Evans A 309
 Ewald C A ■
 Evalto J 327 332
 Famer F B 372 374 375 379 432
 Falconer M A 14 67 see Osterberg
 Faltin R 385 387 393
 Fanconi G 328 332
 Fang H C 177 see Loucks

- Farber H 265 272
 Farr C E 264 272 see Fries
 Farr J P 127 129 see MacFayden
 Farris J M 129 see Collier
 Feinblat H 365
 Feldman M 456 459
 Fender F A 10 73 see White J C
 Fenker 355
 Fernstrom H 384 387 388 393
 Fey A 355 see Cubbins
 Field M F 264 272 see Drinker C
 Filippini G 393
 Fine J 6 16 43 44 67 see Banks
 Sears Hermanson Frehling Starr
 Fuchs Gendel Rosenfeld 131 135
 137 252 see Hurwitz and Mork
 Banks Sears and Hermanson
 Finney J M T 334 338
 Finsterer H 118 123 129 391 393 439
 441
 Firor M 73 see Bernheim and Whipple
 G H
 Fischer A F 328 332
 Fischer A W 313
 Fitz R 316 328
 Fleischbauer F 345
 Fleischner F 311
 Fleisch Thebesius M 347 348 355
 Flint E R 94 211 255 259
 Flint J M 456 458
 Flothow P G 448 449
 Floyd W O 415 417 see Haggard
 Fockens P 267 268 272
 Forrer 327 332
 Forsner H 261 272
 Fortune P T 433 see Coley
 Foss H L 433
 Foster W C 10 51 67 see Hausler
 Fowler W F 338 see Davidson S C
 and Mellon
 Fox N I 59 67 see Mantel and Rabens
 Frankau C 362 365
 Franke K 433
 Fraser J 417 432 see Robbins R H
 Frehling S 67 see Fine and Starr
 Frey H 435 436 442
 Friedell A 336 338
 Friedell M T 67 see Wakefield
 Friend E 365
 Fries M 264 272 see Farr C E
 Frimann Dahl J 252
 Fromme A 362 445 449
 Fruchard H 432 see Peignaux
 Fuchs F 67 see Fine and Gendel
 Gabbianelli L 417
 Gabrielli S 372 379
 Gage I M 443 see Ochsner and Cutting
 Gamble J L 3 8 11 12 13 67 see
 Milver and Ross
 Gamstedt F 407 417
 Cant S G 333 338
 Garber N 379
 Gardner C F 393 426 432 see Hart D
 Garland L H 96 see Hayworth
 Garlock J H 232 235 see Seley
 Carnier M 44 70 see Roger
 Carré C 311
 Garnde E 357 see Ochsner
 Carvin J A 263 272
 Gaskell W H 412
 Gatch W D 10 H 44 67 see Trusler
 Ayres and Lyons 211 240 252 see
 Little 359 365
 Gatewood 375 380
 Gellhorn G 357
 Gendel S 43 58 see Fine
 Genersich A 328 332
 Gentile A 375 380
 Gerard R W 44 68
 Gersuny 285 288
 Gibbins I 441 see Carlson A J and
 Smith E A
 Gibson C L 356 383 393
 Gibson F S 316 322 329 369 378 393
 Gibeon H R 330
 Giffhorn 385 393
 Ginsberg 457
 Gimburg L 310 see Crohn and Oppen
 heimer
 Gir J A 176
 Glenn P M 259
 Glinski 68
 Goehl R O 96 see Lynch Borman and
 Wangensteen
 Gold E 95
 Golden R 96 176 442 see Leigh and
 Swenson P C
 Goldman L 417 see Elman
 Goodall H W 417
 Gordon Taylor G 129
 Gorke H 68
 Gottesman J 417
 Goulband 215 356
 Graham A S 235 see Rankin 299 311
 330
 Graham E A 94 see Walton and
 Moore R M
 Graham R R 188 212 see Brown
 W E
 Granger A 96 see Ochsner
 Grant W W 212
 Grasso R 417
 Graves W P 95
 Green E K 371 379
 Green R M 449 see Kellogg and
 Haivre

- Curschman I 384 393
 Cushing H 120 129 see Livingood
 Cutler F C 14 66 see Pjorn M
 Cutler G D 380 393
 Cutting R A 27 66 443 see Ochsner
 and Gage
 Dack G M 57 68 see Dragstedt I R
 Haerem and Wilson
 David V C 50 see McGill 277 287
 333 337 338 442 see Loring M
 David on S C 338 see Fowler and Mel
 lon
 Davis D I 262 263 272 see Poynter
 C W M
 Davis D M 44 66 see Stone
 Davis H A 136
 Davis M H 323 330
 Day R 449
 Deaver J B 255 259 347 348 355 361
 see Ross C G 393 see Magoun 457
 458 see Ross G G
 DeCowan F I 240 252 see Hardin
 Delbet M P 393
 Delprat G D 268 273 see Weeks
 Demel H 435 442
 Demidova P N 100 115
 Dimmer F 268 272
 Dennis C 207 230 234 235 255 257
 259 302 389 393 397 410 417 see
 Brown M
 Dennis F S 126 129
 Denny F S 261 272 see Sloan L H
 De jardins A 372 373 379
 Deutermann J I 432 see Dixon
 Dewar J W 290 300 378 see Miller
 R H
 Dixon C F 129 see Rivford 176 259
 see Birgen and Schlicke 310 see
 Beaver D C 432 see Deutermann
 Dock W 442 see Hartman H
 Doerfler H 391 393 456 458
 Donovan R J 268 272 378 426 432
 see McIntosh
 Doss A K 156 176
 Dott N M 386 389 393 421 423 425
 426 432
 Doub H H 312 see Jones H C
 Douglas J 454 457
 Dowd C N 213 355 409 417
 Dowdle E 379
 Downes T M 213 see Lee W E
 Dragstedt C A 8 26 33 44 66 see
 also L R 231 235 see Lang and
 Millet
 Dragstedt I R 11 59 66 67 see Ellis
 Montgomery and Matthews 68 see
 Haerem and Dack 426 432 see Hay
 mond
 Drinker C K 50 67 see Field M E
 Drogemueeller E H 69 177 see Ivy and
 Meyer J L
 Drummond H 417
 Duckett J W 433
 Duff G L 130 see Rich
 Dunlap D M 65 see Armour Brown
 T C, Mitchell Seal and Stewart
 Duval R 364 440 442
 Dvorak H J 67 71 191 see Carlson
 H A Lynch Wangen teen Frick
 von T C and Smith V D
 Dwight T 340 315
 Eaton F R 393 see Adams J F
 Eaton F G 252 see Jones C M
 Edington G H 285 287
 Edmunds A 91
 Edwards C R 375 380
 Eggers C 432
 Finhorn M 160 175 176
 Finzendrath D N 433 435 442
 Li berg H B 216 293 309 457
 v Fi el berg A 303 393
 Ewing L H 310 361
 Elia on F L 345 see Erb
 Ehot E Jr 417 see Corncaden
 Filhot J W 454 457
 Elliott A H 330
 Filinger A 70 see Prutz
 Ellis J C 11 67 see Dragstedt L R
 Elman R 59 67 see Cole W H 157
 176 see McCaughan 197 204 211
 215 see Hartmann H R 246 252
 409 417 see Goldman 432 see Hart
 man
 Emery F E 325 331 see Herrick
 Enderlen E 33 45 67 see Hess 120
 179 see Sauerbruch
 Eneboe J B 366 378 see Rigler
 Engstad J E 372 379 442
 Erb I H 264 272 345 see Eliason
 Erdmann J F 311 see Burt 313 see
 Clark H E
 Erkes F 377 381
 Ernst N P 261 272
 Etes W L 206 214 351 355 see Holm
 Eustermann G D 51 59 66 see Brown
 G E Hartman H R and Rown
 tree M 99 129 see Balfour
 Evan A 309
 Ewald C A 94
 Evalto J 327 332
 Fener F B 372 374 375 379 432
 Falconer M A 14 67 see Osterberg
 Faltn R 385 387 393
 Fanconi G 328 332
 Fang H C 177 see Loucks

- Hinchey P R 229
 Hinman I 9
 Hinrichsen J 32 69 *see* Ivy
 Hintz R 297 312
 Hintze A 393
 Hirschprung H 338 412 417
 Hirschfeld S 213 *see* Hyman and Wanger
 Hoag C I 212
 Hodge F H 288
 Ho Duc Di 331 *see* Huyoh Tien Doi
 van der Hoeven I C T 315
 Hofer R 412
 Hoffmann W 325 326 327 331
 von Hofmeister 326 331 438
 Hoguet J P 3 68 *see* Hartwell
 Holden W B 197 209 215 255 259 350
 Holm C I 206 214 313 351 355 356 *see* E. tes
 Holt R I 55 68
 Holz F 317 379
 von Hommes J H 380
 Homans J 391
 Hooper C W 176 215 *see* Whipple G H
 Horine C F 352 355 365
 Horsley J S and G W 213 220 225 235 *see* Bigger 293 294 311 312 *see* Coleman
 Hotz G 45 68 151 176 435 436 440 442
 Hubbard J C 434
 Huddy G P H 399 418
 Hudson H W 434
 Hugh on W 68 151 1 6 440 442 *see* Scarff
 Hume J B 378
 Hunt V C 85 440 442
 Hunter J 175 176
 Hunter R H 346
 Hurst A T 128 *see* Babey
 Hurwitt E S 253 *see* White J C Whitelaw and Sweet W H
 Huruya S 394
 Huyoh Tien Doi 331 *see* Ho Duc Di
 Hyman H T 213

 Iglauer H 171 172 177 *see* Molt
 Ingwaldsen I 44 68 *see* Whipple A O and Bauman L
 Irons E H 70 *see* Moody
 Irvin J L 253 *see* Penberthy
 Ivy A C 8 17 H 69 *see* Hinrichsen 177 *see* DrogemueUer and Meyer J L 202 203 215 *see* Scott

 Jaboulay 262 272
 Jackman W A 311
 Jackson C E S 345
 Jackson J 452 454 457 *see* Quinby and Porter
 Jackson H 458
 Jacobsen H 384 394
 James R 380
 James T G D 311
 January D A 391 *see* Smith F B
 Jeanbreaux I 372 379 *see* Riche
 Jeffries J W 391
 Jenkins H I 10 H *see* Beswick
 Jensen V K 232 234 235 *see* Johnrud and Nelson
 Jerrault F N C 456 *see* Washburn
 Jeset 411 418
 Jobling J W 44 69 *see* Meloney and Berg
 Joffe I I 459
 John on F 262 272
 Johnson H I 357
 Johnson J A 431
 Johnsrud 232 234 235 *see* Jensen and Nelson
 Johnston C G 161 164 165 175 176 *see* Abbott W O 177 213 255 259 *see* Penberthy Noer Kenning and Ravdin
 Jones C M 252 *see* Eaton
 Jones H C 312 *see* Doub
 Jones J C 418
 Jones T B 426 432 *see* Morton J J
 Jone T E 310 *see* Collins
 Jop on 454 457
 Joyce J I 435 442
 Joyce T M 365
 Judd F S 264 267 272 *see* White R B 303 314 *see* Pollock 338 *see* Ad on and Thompson
 Jukes F 175 177

 Kader B 69
 Kagan M 49 69
 Kaser F J 450
 Kalbfleisch W H 96
 Kaldar J 272
 Kallio K E 348 356 383 384
 Kanavel A B 175 177
 Kantor J L 16 69 311
 Kappis M 93 175 177 442
 Karelitz S 433 *see* Aschuer
 Kasemeyer E 397 418
 Kaufman E 347 356
 Kausch W 314 400 418 438 442
 Keith A 274 276 277 282 283 365 378 394 421 422 423 432
 Keith N H 213 245 252
 Kelling G 323 330
 Kellogg F S 449 *see* Green R M and Huve
 Kelly R E 325 331

- Greene D 337 see Barenberg and Greenspan
 Greene I I and J 331
 Greenspan I 337 see Barenberg and Greene D
 Greenwood W F 14 68 see Haast and Taylor
 Gregerson M I 134 137
 Grekow I I 393
 Grey Turner G 329
 von Greyerz W 313
 Grudner A 393
 Groper M J 400 417
 Gross M 176
 Gross O 129 see Culeke
 Gross R F 268 273 336 338 see Ladd 426 431 see Blodgett
 Cuillume 34 348 356 366 377
 Cuiron N M 356
 Culeke N 129 see Gross O

 von Haberer H 306 313 316
 von Hacker 206 215
 Haden R L 10 68 213 see Orr T G
 Hadra 274
 Haerem S 57 59 68 see Duck and Dragstedt
 Haggard W D 313 415 417 see Floyd W O
 Haast R F 14 68 see Greenwood and Taylor
 Haave I I 449 see Green R M and Kellogg
 Hall H 186 187 212 see Novak
 Halpern H 264 267 271 see Cannon P R
 Halpert B 316 379
 Halsted A E 324 330 431
 Halsted W S 216 218 219 221 223 225 226 228 229 235 307 308
 Hamilton C H 272 279 288
 Hamilton W F 244 251 see Burbour
 Handley W 214 439 442 444
 Hanke H 317 329 431 431
 Hannson A 290 309
 Hanson H J 259 see Kennedy C C
 Hardin R C 240 252 see DeCowan
 Hardoun E 286 288 393
 Hargrave R L and R 331
 Harken D E 288
 Harkins H N 137 417 431
 Harpoth H 331
 Harrigan A H 356
 Harrington S W 369 378
 Harris F I 311 see Bell S H and Brunn
 Harrison G K 72 see Taylor and Weld
 Hart D 426 432 see Gardner
 Hartman A F 204 215 see Elman
 Hartman H 412 see Dock W
 Hartman H R 66 see Brown O E., 204 215 see Walters W
 Hartwell J A 3 68 see Hoguet
 Harvey S C 386 393
 Haselhorst O 330
 Haless H D 9, see O good
 Hauser R W 10 67 see Foster
 Havens A P 317 330
 Hawking F 233 234 235
 Hay I 28 68 232 235 236 see Varco and Stevens 453 457
 Haymond H F 372 380 393 432 458 see Dragstedt I R
 Hayworth J B 96 see Garland
 Head H 93
 Heibloom C A 366 369 378
 Heggs F M 313
 Heidenham I 438 442 445 449
 Heiman J D 413 see Ransohoff
 Heiman H 449 450 see Cohen I
 Heine J 312
 Heinz T F 313
 Heise W 393
 Heller F 176
 Hellström J 312 331
 Hellstrom N 297 309
 Helmholtz H 264 272
 Helsted A 413 416 see Arntzen
 Hemmeter J C 175 176
 Hendon G A 213
 Hendrix B M 58 72 see Sweet and Peet
 Henning 317 329
 Henchen C 399 417
 Herminson I 67 137 see Banks
 Herrell W F 431 see Waugh and Crumpler
 Herrick C A 325 331 see Emery
 Herrick J B 93
 Herrin R C 38 40 68 134 137 see Meek
 Hertz A I 95
 Hertzler A F 95 214
 Heschl 30 31 68 300 313 328 332
 Hess 33 67 see Funderlen
 Hess J H 377 see Bettman R B
 Hettwer J P and K R 59 68
 Hibbard J S 20 24 59 68 437 442 457 see Kremen and Wangenstein
 Hidde F G 236 see Schmidt Current and Adishek
 Higgins C C 346
 Higgins G M 129 see Beaver M G and Lemon
 Hild J R 328 332 see Adamson
 Hill F C 60 68 100 115 see O Loughlin see Stoner
 Hilton J 129

- Livingood L E 120 129 see Cushing
 Livingston E M 95
 Loar L 332 see Markowitz B
 Lockhart Mummery J I 314
 Lofstrom J F 96 see Voer
 Loitman C 268 273
 Lombard P 379
 Longacre J J 372 380
 Loop R C 458
 Lord J P 356
 Lord M P 213
 Loring M 439 442 see David
 Lot ch F 288
 Loucks H 177 see Fang
 Loucks M 46 51 72 see Wangen teen
 Louris H W 59 66 see Colp
 Lout ch M H 418
 Lovelace W R 136 137 308 see Mayo
 C W
 Lowe E R 177 see McClendon Bissell
 and Meyer P F
 Lower W E 415 418 434
 Lowman R M 379 see Wassung
 von Ludwig F 340 345
 Lufkin N F III 69 384
 Lynch F W 46 66 see Carlson and
 Wangen teen 96 see Goehl Borman
 and Wangen teen
 Lynn D 232 235 see Hay I J and
 Wangen teen
 Lyons R E Jr 44 67 see Gatch and
 Trusler

 McCann J C 348 356
 McCaughan J M 157 176 see Eiman
 McClendon J F 161 177 see Bissell
 Lowe Meyer and Medes
 MacFarlane W D 416 see Cameron
 J A M
 MacFayden D A 127 129 see Farr
 L E
 McFetridge E M 212 see Moss 258
 see Boyce
 McGill 50 66
 McGlannan A 255 259
 McGraw J J 253 see Strumia
 McGregor A L 214 444
 McGuire S 458
 McIndoe A H 129
 McIntosh C A 28 70 see Owings Stone
 and Weinberg
 McIntosh R 273 426 432 see Donovan
 E J
 McIntyre A H 65 see Bagard and
 Osheroff
 McIver M A 3 11 15 16 20 57 69
 212 see Benedict Chne Lawson &
 Redfield 254 259 359 365
 McKenna C H 214
 McKenna H 443
 MacKenzie J 93 95
 McKinnon A I 213 356 455 458
 McKittick L A 3 69 88 see Sarr
 S P 100 109 115 212 254 255 256
 257 259 309 312 see Sarris
 MacLennan A 268 273
 McLean A 69 see Andries
 McLean F H 326 331
 MacNaughton E A 215
 MacNeal J 44 69 see Chae
 McQuarrie I 59 69 see Whipple G H
 McWhorter G L 318 329 346
 Maddock W G 18 66 133 136 172
 173 176 240 243 252 see Collier
 Bartlett Bingham and Pedersen
 Magoun J A H 376 381 see Mayo
 C H., 457 see Deaver J H
 Maier O 311
 Major S G 311 see Rankin
 Makins G H 119 129 391 394
 Mall F P 33 115 309 432
 von Mandach G 345
 Manson M H 92 95 see Rigler
 Mantel F J 67 see Fox and Rabens
 Marek J 398 418
 Markowitz B 332 see Loar
 Markowitz J 433 439 see Campbell
 W R
 Martzloff A H 65 235 375 443 see
 Burget G E
 Marsh H E 418
 Mason V R 397 416 see Chaffin and
 Slemons
 Masson J C 375 380 see McIndoe
 381 see Atkinson
 Matas R 175 177 283 288
 Mattershead S 406 416 see Barlow T
 Matti H 396 418
 Maycock W 55 58 69
 Mauro M 394
 Mayer A 450
 Mayo C H 213 308 369 376 378 381
 see Magoun
 Mayo C W 308 314 see Lovelace 410
 418 see Phillips R 450 see Borgen
 Mayo W J 235 303 308 314
 Mayo-Robson A W 317 379
 Mead C H 205 215 312
 Meccray P M 235 252 see Barden and
 Ravdin
 Medes G 177 see McClendon
 Medinger F G 293 314
 Meek A J 8 38 40 68 134 137 see
 Herrin
 Melchior E 212 214 383 394 438 443
 450

- Kelsey C B 281 288
 Kelynack T N 430 431
 Kendall A I 120 129
 Kennedy C C 259 see Hanson H J
 Kenning J C 175 177 see Johnston
 Penberthy and Noer
 Kenyon J H 216 see Pool
 Kerr 219 235 see Parker
 Key I 378
 Keyes F I 214 see Middleman
 Kiefer H D 312
 Kiesselbach 325 331
 Kilgore A M 157 178 see Walters and
 Bollmann
 Kim S 8 69 177
 King F S J 432
 Kirby F J 394
 Kirk J R 331
 Kirschner M 203 204 215 252 412
 Kirsner J B 418 see Miller J F
 Klein E 454 457
 Kleinschmidt O 338
 Klendshof N 253 see Witcheby and
 Swan on P
 Klobber H 323 330
 Knight G C 60
 Knight C S 46 55 56 58 69 see Stone
 188 212
 Knight R 188
 Knoopp L F 259 see Phillips J R
 Koch A 418 see Oerum
 Koch E 381
 Koch E 381
 Koch W 432
 Koenig E 274 288 345 394
 Konjetzny G L 338
 Kornblith H A 328 332 see Otani S
 Korte W 298 303 304 314 329 445
 446 448 450
 Koster H 207 216 392 394
 Koucky J D 212 see Beck W C
 Krall 377 381
 Kreis P 345
 Kremen A J 188 197 198 209 216 see
 Sperling
 Kreuter 261 272
 Krogus A 213 438 442
 Kronlein R 361 365
 Kubota T 357
 Kuliga P 262 272 329
 Kummer E 374 380
 Kuntz A 442
 Kussmaul 175
 Kuttner H 366 377 383 394

 Lacey J T 357
 Ladd W E 268 270 271 272 273 288
 336 338 342 346 394 418 426 428
 429 430 431 432 see Gross R E,
 434
 Ladwig A 356
 Læwen A 69 197 209 216 288 333
 337 338
 Lahey F H 314
 Lajon G 413
 Lamson O M 415 418
 Landis F M 43 69
 Landry H B 397 417 see Clifton
 Landsteiner 327, 332
 Landvert 373
 Lang 26 33 see Dragstedt C A and
 Millet
 Langley C F 369 377 379 382 441
 Larimore J W 395 391
 Larson I M 451 458
 Larson W P 66 see Bellis Stevens H
 and Wangenstein
 Laurell H 96 326 331 384 391
 Law A A 288
 Law J I 336 338
 Law G M 454 458
 Law on H 40 65 see Antonie 69 see
 Chumley
 Learmonth J R 335 338 see Rankin
 448 450 see Rankin
 Lecene P P 385 391
 Lee W F 213 see Downes
 Lehman E P 353 357 see Boys
 Leichtenstern I 311 316 329
 Leigh O C Jr 96 see Golden and Swen
 son 164 177 see Nelson J A and
 Swen on 255 259
 Lemon W M 129 see Higgins and
 Beaver M G
 Lennander H G 441 443
 Lerche R 93
 Leuenberger G 66
 Leven N L 17 72 see Wangen teen
 Levin A L 164 175 177
 Levin J J 326 331 see Porter
 Levine S 97 see Cohen L and Solis
 Levitin J 115 see Brunn
 LeWald L 378
 Lewin M M 443
 Lewis E E 418
 Lewis E J 255 259 see Shapiro and
 Vaughn
 Ley L 356
 Licht E 96
 Liebe H 389 394
 Liebhien V 316 329 see Wolfer A
 Ligat D 394 see Overend
 Lindgren U 213
 Lindner H H 273 see Saunders J H
 Lindsay E C 396 403 409 411 412
 419 see Perrin

- 209 212 216 297 333 see Storek
 A H and Roth child J I 316 337
 see Caside 436 439 413 see Cage
 and Cutting
 Oelschirt N C 311
 Oehlecher I 393
 O'Loughlin B J 110 115 see Hill and
 Stoner
 Olivecrona H 435 413
 Ol on H 419
 Ol on Y 413 418 see Pallin
 Oppenheimer C D 310 see Crohn Yu
 nich Otto and Spindler
 Orr H W 120 130
 Orr T C 212 362 369 378 see Voff
 413 see Haden
 O good I I 90 see Haskins
 O heroff W 62 see Bigard and Mc
 Intyre
 Oler W 95 407 410
 O terberg A F 14 67 see Falconer
 Otani S 328 332 see Hornblith
 Otto C F 331 see Carl and Spindler
 Oughterson A W 415 419 see Cheever
 Overend T D 391 see Ligat
 Owings J C 28 70 see McIntosh Stone
 and Weinberg

 Page F 281 285 288
 Page M 288 412 419
 Pagenstecher F 90
 Paine J R 6 29 70 94 96 see Rigler
 132 135 136 137 see Armstrong
 Lynn and Key 143 145 156 175
 177 see Carlson and Wangenstein
 253 265 see Wangenstein 280 288
 see Neva 443
 Pallin G 413 418 see Ol son
 Paltuf A 328 337
 Pan N 380
 Pansdorf H 312 331
 Parker E M 216 219 235 see Kerr
 H H
 Parkes C T 119 130
 Purry R H 409 419
 Passler H W 337 338
 Pitts on A C 314
 Paul M 380 see Hill W C O
 Paul F T 308 314
 Payr A 344 386 396
 Par e H E Jr 10 11 70 see Morton
 206 214 351 356
 Peet M 58 72 see Sweet and Hendrix
 Pehu M 273 see Auterge
 Peignaux 425 432 see Fruchard H
 Pemberton J 452 453 458
 Penberthy G C 177 see Johnston
 C G Noer Henning 253 see Irvin
 Pendergras E P 116 178
 Penoyer G I 311
 Perlman J 392 393
 Perrin W S 396 403 409 411 412
 419
 Perthe C 212 333 337 338 392 393
 Peters G A 85 90 437 413
 Peters J I 137 213 253
 Peters K O 356
 Peterson C H 326 327 331 see Archer
 Peterson I 347 356
 Peyton W T 170 178
 Pfahler G F 431 431
 Pfanner W 379 see Staunig
 Philppowicz W 391 395
 Phillips J R 331 see Knoepf
 Phillips R 410 418 see Mayo C W
 Iby ick I S 175 178
 Iyuan B 14 66 see Cutler
 Iones B 395 see Rabinovitch and Bil
 ler
 Ilatou E S and R V 407 419
 Plew H 326 332
 Ioli A 406 419
 Iollock I W 303 314 see Judd
 Pool E H 35 see Kenyon 216
 Iorger H 314
 Iorter A 331 see Levin J J
 Iorter M F 292 311 452 454 459 see
 Jack on and Quinby
 Portmann U V 433 see Crile
 Iorzelt W 314
 Ioth F J 217
 Iotter F B 215
 Power D 400 419
 Ioynter C W M 272 see Davis D L
 Poynton F J 389 395
 Irait G H 159 175 178 439 443
 Iribram B O 377 382
 Price I 434
 Propping 419
 Prutz W 33 70 see Ellinger 381 see
 Monnier

 Quinby W 452 454 457 see Jack on J
 and Porter C

 Rabens J J 67 see Fox and Mantel
 Rabinovitch J 395 see Pines H
 Rabam M H 70
 Rademacher L 293 312
 Ragins A H 330 see Shrager
 Raiford T S 290 291 294 310
 Ralphs F C 443
 Randall O S 291 311
 Rankin F W 220 235 see Graham
 A S 299 311 see Major 312 314
 see Chumley 315 see Scholl 334
 335 338 see Bagen Blue and Lear
 month 448 450 see Learmonth

- Meloney F I 44 69 *see* Jolting and Berg
 Mellon R R 339 *see* Fowler and Davison
 Meltzer S 328 332
 Mening F H 212
 Mercier 280 288
 Merola 456 459
 Meukowicht I 179
 Meyer J I 453 454 458
 Meyer H A 311 *see* Ross
 Meyer I 315
 Meyer P I 177 *see* McClendon III
 sell and Lowe
 Michael P 131 *see* Bell H C
 von Mickulicz T 303 308 311 390 392
 Middleman I C 214 *see* Hayes
 Millbourn I 323 330
 Miller C J 212 255 259
 Miller I M 268 273 369 391 418
 Miller J F 418 *see* Harner
 Miller I I 252 *see* Ross J F and Whipple G H
 Miller N F 258
 Miller R H 378 *see* Dennis 426 430
 431 *see* Wallace
 Miller R T 299 300 314
 Miller T C 161 162 175 *see* Abbott
 W O
 Millet 26 33
 Mills R W 312
 Minot A S 253 *see* Bialock
 Mirizzi I I 335 339
 Mitchell G F 372 379
 Mitchell T C 65 *see* Armour Brown
 T G Dunlap Pearl and Stewart
 Mixer S J 212
 Moll H H 432 434 *see* Bell H G
 Molnar B 70
 Molt W F 171 172 177 *see* Ighuer
 Monk G H 183 193 197 209 210
 216
 Monnier E 381 *see* Prutz
 Monot T B 310
 Monrad S 396 402 413 418
 Montgomery A H 409 418 431 434
 Montgomery L G 130
 Montgomery M O 9 70 *see* Swandt
 J M
 Moody W B 70 *see* Irons
 Moon V H 38 70 *see* Morgan
 Moore R M 94 *see* Walton and Gr
 ham E A
 Morgagni 280 288
 Morgan D R 38 70 *see* Moon
 Moritz A R 394
 Morley J 93 273
 Morris J H 365 *see* Johnson V S
 Morc R W 110 115 447 450 *see* Vas
 lund
 Mort S 310
 Mortality Statistics Bur of Census 70
 Morton J J 11 27 28 36 49 70 *see*
 Pearce and Sullivan W D 72 *see*
 Stabius 130 205 214 273 356 378
 380 391 426 432 *see* Jones T H
 450 *see* Scott W J M
 Machcowitz A V 361 365 391 *see*
 Wilenki A O
 Moss W 212 *see* McFetridge
 Movshin B C A 130 235 379 349
 352 356 372 376 377 380 391 389
 418 459
 Mrack 328 332
 Mugler F R 331 *see* Terry
 Muh um R 70
 Muller C I 347 356 *see* Rademaker
 Muller W 315
 Mumez N 312
 Murphy J B 323 329 330 337 381
 445 446 450
 Muschkatov W I 207 216 234 235 314
 392 394
 Myerson A 449 450 *see* Ritvo
 Neshund J 290 310
 Nagel G W 372 374 380
 Nalund A W 110 115 *see* Morc
 Neff F C 378 *see* Orr T G
 Nelson A R 319 329
 Nelson J A 164 177 *see* Leigh and
 Swenson
 Nelson M C 232 234 235 *see* Jen en
 and Johnrud
 Nemir A 379 *see* Callander
 Nesbitt H 44 70
 Nessa C B 280 288 *see* Paine
 Neugebauer F 337 338
 Ngai S K 310 *see* Tung
 Nitck C A R 290 310
 Nixon S 177
 Noer R J 96 *see* Lofstrom 177 *see*
 Johnston C G Penberthy and
 Kenning
 Norbury I E C 288
 Nordman O 314
 Nordentoft J M 413 418
 Northrup R F 177
 Nothnagel H 293 294 312 418
 Novak M 186 187 212 *see* Hall H
 Novikov G M 440 443
 Noyer E 311
 Nygard K K 434 *see* Walters W
 Obalinski A 212 384 391 395
 Oberndorfer 294 312
 Ochner A 96 *see* Granger 151 197

- 209 212 216 297 333 see Storck
 A H and Roth child J F 316 357
 ee Carside 436 439 443 see Cage
 and Cutting
 Ochsenhut N C 311
 Ochlecher F 393
 O Loughlin B J 110 115 see Hill and
 Stoner
 Olivecrona H 435 413
 Ol on H 418
 Olson Y 413 418 ee Pullin
 Oppenheimer C D 310 ee Crohn Yu
 nich O to and Spindler
 Orr H W 126 130
 Orr T G 212 362 369 375 see Veff
 443 see Haden
 O good F E 93 ee Haling
 O heroff W 65 see Bignard and Mc
 Intyre
 Oler W 95 407 419
 Osterberg A E 14 67 ee Falconer
 Otani E 328 332 see Hornblith
 Otto G F 331 see Cort and Spindler
 Oughterson A W 415 419 ee Cheever
 Overend T D 391 ee Ligat
 Owings J C 28 70 see McIntosh Stone
 and Weinberg

 Page F 281 285 288
 Page M 288 412 419
 Pagenstecher F 83
 Paine J R 6 29 70 91 96 see Rigler
 132 135 136 137 see Armstrong
 Lynn and Keys 143 145 156 175
 177 see Carlson and Wahngreen
 253 255 see Wangen teen 280 288
 see Nessa 443
 Pallin G 413 418 ee Olson
 Paltauf A 328 332
 Pan N 380
 Pansdorf H 312 331
 Parker E M 216 219 233 see Kerr
 H H
 Parkes C T 119 130
 Parry R H 409 419
 Passler H W 337 348
 Patton A C 314
 Paul M 380 ee Hall W C O
 Paul F T 308 314
 Payr A 344 386 393
 Pearce H E Jr 10 11 70 ee Morton
 206 214 351 356
 Peet M 55 72 see Sweet and Hendrix
 Pehu M 27 ee Auberge
 Peignaux 425 432 see Fruchard H
 Pemberton J 452 453 458
 Penberthy G C 147 see Johnston
 C G Norr Kenning 233 see Irwin
 Pendergras I P 116 178
 Penoyer G I 311
 Perlman J 392 397
 Perrin W S 396 403 409 411 412
 419
 Perthes C 212 333 337 338 392 393
 Peters C A 88 93 437 413
 Peters J I 137 213 253
 Peters K O 356
 Peterson C H 326 327 331 see Archer
 Peterson I 347 356
 Peyton W T 170 178
 Pfahler G F 431 434
 Pinner W 379 see Staunig
 Philippowicz W 391 395
 Phillip J H 331 see Knoopp
 Phillip R 410 418 ee Mayo C W
 Iby ick P S 175 178
 Pjosen H 14 66 ee Cutler
 Pines B 393 ee Rabinovitch and Bil
 ler
 Platon F S and R V 407 419
 Plew H 326 332
 Lohd A 406 419
 Pollock L W 303 314 ee Judl
 Pool F H 33 see Kenyon 216
 Porges H 314
 Porter A 331 ee Irwin J J
 Porter M F 292 311 452 454 459 see
 Jack on and Quinby
 Portmann L V 433 see Crile
 Porzelt W 314
 Poth E J 217
 Potter F B 215
 Power D 400 419
 Poynter C W M 272 see Davis D L
 Poynton F J 389 393
 Pratt G H 159 175 178 439 443
 Pribram B O 377 382
 Price I 434
 Propping 419
 Pruitt W 33 70 ee Ellinger 331 see
 Monnier

 Quinby W 452 454 457 see Jackson J
 and Porter C

 Rabens J J 67 see Fox and Mantel
 Rabinovitch J 393 ee Pine B
 Rabwin M H 70
 Rademacher L 293 312
 Ragins A B 350 ee Shrager
 Raiford T 290 291 294 310
 Ralphs F G 443
 Randall O S 291 311
 Rankin F W 220 235 ee Graham
 A 299 311 ee Major 312 314
 see Chumley 315 ee Scholl 334
 335 338 see Birgen Bue and Lear
 month 448 450 ee Learmonth

- Melency F I 44 69 see Jobling and Berg
 Mellon R R 338 ee Fowler and Davidson
 Meltzer S 328 332
 Mensing T H 212
 Mercer 280 288
 Merola 456 459
 Meulengracht I 129
 Meyer J I 453 454 458
 Meyer K A 311 see Ro
 Meyer I 315
 Meyer P I 177 ee McClelland Buell and Lowe
 Michael I 431 see Bell H C
 von Mickulitz T 303 308 311 390 392
 Middleman I C 214 see Keyes
 Millbourn T 323 330
 Miller C J 212 255 259
 Miller I M 268 273 369 391 418
 Miller J F 418 ee Kirner
 Miller I I 282 see Ross J F and Whipple G H
 Miller N I 288
 Miller R H 378 see Dewar 426 430 431 see Wallace
 Miller R T 299 300 314
 Miller T C 161 162 175 see Abbott W O
 Millet 26 33
 Mills R W 312
 Minot A E 253 see Block
 Mirizzi I I 335 339
 Mitchell G F 372 379
 Mitchell T C 88 see Armour Brown T G Dunlap Pearl and Stewart
 Mixer S J 212
 Moll H H 432 434 see Bell H G
 Molnar B 9 70
 Molt W F 171 172 177 see Iglaier
 Monks G H 183 193 197 209 210 216
 Monnier F 381 see Prutz
 Monot T H 310
 Monrad S 396 402 413 418
 Montgomery A H 409 418 431 434
 Montgomery L G 130
 Montgomery M O 9 70 ee Swandt J M
 Moody W H 70 see Irons
 Moon V H 38 70 see Morgan
 Moore R M 94 see Walton and Graham E A
 Morgagn 280 288
 Morgan D R 38 70 ee Moon
 Moritz A R 394
 Morley J 93 273
 Morris J H 365 see Johnson V S
 Morse R W 110 115 447 450 see Naslund
 Mort S 310
 Mortality Statistic Bur of Census 70
 Morton J J 11 27 28 36 49 70 ee Learse and Sullivan W D 72 see Stehns 130 205 214 273 356 379 380 391 426 432 ee Jones T B 450 see Scott W J M
 Ma cheowitz A V 361 365 381 see Wilenky A O
 Moss W 212 ee McFetridge
 Moynihan B C A 130 235 379 349 352 356 372 376 377 380 391 382 418 450
 Mruck 328 332
 Mugler I R 331 see Terry
 Muh am R 70
 Muller G P 347 356 ee Rademaker
 Muller W 315
 Mumez N 312
 Murphy J B 323 329 330 337 381 445 446 450
 Muschkatia W I 207 210 234 235 314 392 394
 Myerson A 449 450 ee Ritvo
 Naslund J 290 310
 Nagel C W 372 374 380
 Naslund A W 110 115 ee Morse
 Neff F C 378 ee Orr T G
 Nelson A R 319 329
 Nelson J A 164 177 ee Leigh and Swenson
 Nelson M C 232 234 235 see Jensen and Johnrud
 Nemir A 379 see Callander
 Ne bitt B 44 70
 Ness C B 280 288 see Paine
 Neugebauer F 337 339
 Ngai S K 310 ee Tung
 Nit ch C A R 290 310
 Nixon S 177
 Noer R J 96 ee Loftrom 177 ee Johnston C G Penberthy and Kenning
 Norbury L E C 288
 Nordman O 314
 Nordentoft J M 413 418
 Northrup R F 177
 Nothnagel H 293 294 312 418
 Novak M 186 187 212 ee Hall H
 Novikov G M 440 443
 Nover E 311
 Nygard A K 431 ee Walters W
 Obahn L A 212 384 391 395
 Oberndorfer S 294 312
 Och ner A 96 ee Granger 151 197

- 209 212 216 297 333 see Storck
 A H and Roth child J I 346 347
 de Carside 436 439 443 see Clegg
 and Cutting
 Ochelhurt N C 314
 Ochlecher F 395
 O'Loughlin B J 110 115 see Hill and
 Stoner
 Olivecrona H 435 443
 Olsson H 418
 Olson Y 413 418 see Illin
 Olpenheimer C D 310 see Cronin Yu
 nich O to and Spindler
 Orr H W 176 180
 Orr T C 217 362 369 378 see Neff
 413 see Haden
 O'good F F 9a see Hawkins
 Oheroff W G see Bigard and Mc
 Intyre
 Oler W 9a 407 419
 Osterberg A E 14 67 see Falconer
 Otani S 328 332 see Hornblith
 Otto G F 331 see Cort and Spindler
 Oughterson A W 415 419 see Cheever
 Overend T D 391 see Ligat
 Owings J C 28 70 see McIntosh Stone
 and Weinberg

 Page F 281 285 298
 Page M 288 412 419
 Pagenstecher F 9a
 Paine J R 6 29 70 91 96 see Rigler
 132 135 136 137 see Armstrong
 Lynn and Keys 143 145 156 175
 177 see Carlson and Wangensteen
 253 265 see Wangensteen 280 288
 see Ness 443
 Pallin G 413 418 see Olson
 Paltauf A 328 337
 Pan N 380
 Pansdorf H 312 331
 Parker E M 216 219 23a see Kerr
 H H
 Parkes C T 119 130
 Parry R H 409 419
 Pa'ler H W 337 338
 Patten A C 314
 Paul M 380 see Hill W C O
 Paul F T 308 314
 Pavr A 344 386 39a
 Pearce H E Jr 10 11 70 see Morton
 206 214 351 366
 Pett M 88 12 see Sweet and Hendrix
 Pehu M 273 see Auberge
 Peignaux 425 432 see Fruchard II
 Pemberton J 452 453 458
 Penberthy G C 147 see Johnston
 C G Noer Kenning 263 see Irwin
 Pendergras F P 116 178
 Penoyer G I 311
 Perlman J 392 39a
 Permin W S 396 403 409 411 412
 419
 Perthes C 212 333 337 338 392 39a
 Peters C A 85 9a 437 443
 Peters J I 137 213 253
 Peters K O 3a6
 Peterson C H 326 327 331 see Archer
 Peterson I 347 3a6
 Peston W T 170 178
 Pfahler G I 431 434
 Pfanner W 379 see Stauning
 Philppowicz W 391 39a
 Philip J R 331 see Knoepp
 Phillip R 410 418 see Mayo C W
 Physik P S 175 178
 Pijuan H 66 see Cutler
 Pines B 395 see Rabinovitch and Bil
 ler
 Platou I S and R V 407 419
 Plew H 326 332
 Pohl A 406 419
 Pollock I W 303 314 see Judd
 Pool E H 3a see Kenyon 216
 Porge H 314
 Porter A 331 see Levin J J
 Porter M F 292 311 452 454 459 see
 Jackson and Quinby
 Portmann L V 433 see Crile
 Porzelt W 314
 Poth E J 217
 Potter F B 215
 Power D 400 419
 Poynter C W M 272 see Davis D L
 Poynton F J 389 39a
 Pratt G H 159 175 178 439 443
 Pribram B O 377 382
 Price I 434
 Propping 419
 Prutz W 33 70 see Ellinger 381 see
 Monnier

 Quinby W 452 454 457 see Jackson J
 and Porter C

 Rabens J J 67 see Fox and Mantel
 Rabinovitch J 39a see Pines B
 Rabam M H 70
 Rademacher L 293 312
 Ragins A B 380 see Shrager
 Raiford T S 290 291 294 310
 Rajhs F G 413
 Randall O S 291 311
 Rankin F W 220 235 see Graham
 A S 299 311 see Major 312 314
 see Chumley 315 see Scholl 334
 335 338 see Borgen Buie and Lear
 month 448 450 see Learmonth

- Ranchoff J L 443 see Heiman J D
 Ranzi F 45 66 see Clairmont
 Ravdin I S 176 178 see Abbott W O
 and Johnston C G 190 214 233
 235 see Meery Rhoads and Lock
 wood 246 248 253
 Rea C F 17 111 119 72 353 357 431
 431 see Wangenstein
 Redfield A C 15 69 see McIver and
 Benedict
 Reed L B 458
 Reichel P 310 312
 Reid R 377 381
 Reimer H 450
 van der Reis 178 see Schambra
 Rhodes G H 31 70 see Saeltzer
 Rice C O 279 280 see Wangenstein
 Rich A H 130 see Duff
 Richardson F P 255 259 349 357
 381
 Riche V 372 370 see Jeanbraun
 Richter H H 254 259 268 273
 Rigler I G 92 95 see Manson M H
 328 see Boyden 329 see Borman and
 Noble 334 366 378 see Finckh 395
 see Lipschultz 413
 Ritchie H P 258
 Ritchie W H 282 288
 Ritvo M 449 450 see Myerson
 Rivford E 129 see Dixon 386 390 429
 432 433
 Robb J J 443
 Robbins R H 432 see Frazer J
 Roberts G M 178 see Crandall
 Robertson C 268 273 see Sweet G B
 Robertson D E 339
 Robertson G 346
 Robscheit Robbins F S 251 see Whip
 ple G H
 Robson J A 212
 Roden S H 70
 Roger H 44 70 see Garnier
 Roller C S 382
 Rose W C 246 253
 Rosenfeld L 137 see Fine
 Ross G G 11 347 348 355 see Deaver
 J B 458
 Ross J 93
 Ross J W 376 381 see Bruce
 Ross S G 67 see Gamble
 Rost F 325 332 398 419
 Rothschild J E 323 330 see Storck and
 Ochsner
 Rothschild N H 217 293 311 458
 Rowntree L G 8 70
 Royle N D 335 337 see Wade 339
 449 450
 de Rudder R 443
 Rusk G Y 379 see Collander and
 Nemir
 Russell R H 365
 Rutherford H 409 419
 Ryle J A 93 450
 Saeltzer D V 31 70 see Rhodes G H
 315
 Saint J H 310 315
 Salzer F 206 214
 Sampson H 206 310 see Brown I
 Sampson J A 310
 Samson W 137
 Sarria S P 3 69 100 109 115 254 256
 257 259 309 312 see McWhittrick
 Sauerbruch F 120 129 see Funderlin
 378 see Chaoul H and Adam A
 Saunders J B 273 see Lindner
 Savariaud 273
 Sawyer C F 365
 Scammon R E 459
 Scarff J C 151 176 440 442 See Hugh
 son
 Schiempp A 49 70
 Schiembra F W 27 72 161 178 see
 van der Reis
 Schiffbauer H F 355 357
 Schlaepfer K 350 439 414
 Schlicke C P 255 259 see Borgen and
 Dixon
 Scholefield B A 46 71
 Schloessmann 325 332
 Schmidt E R 230 see Current Hidde
 and Adashek
 Schmieden V 315 see Westhues
 Schridde H 261 273
 Schuller 317 329
 Schwartz E 15 71 96
 Schwartzman J 407 419
 Schwyzer H C 160 178
 Scott F H 410 419
 Scott H G 17 44 52 53 55 57 71 96
 see Dvorak Borman and Wangen
 steen 197 202 203 215 see Ivy
 365
 Scott W J M 336 339 see Morton
 447 448 450 see Morton J J
 Scudder C I 254 259
 Scudder J 14 137 185 214 see Zwemer
 and Whipple 293
 Searls H H 65 see Armour Brown
 Dunlap Mitchell and Stewart
 Sears J H 137 see Banks and Fine
 Seley G P 233 235 see Garlock
 Senn N 119
 Shapiro P 259 see Lewis and Vaughn
 Shaw E A 415 419
 Shaw J J M 331

- Sheldon W P H 261 264 273
 Shelley H J 214 365 419
 Sherren J M 0
 Shimodaira V 30 71 300 303 315
 Short A R 377
 Shrager V I 380 see Ragins
 Shuger M 71 see Arnold
 Simpson W M 310
 Sims M 120
 Singleton A C 159 178
 Singer H A 95 97 448 450 see Steigmann
 Sivertsen I 164 178 357
 Sjovald E 458
 Skinner H I 459
 Slemon J M 397 416 see Chaffin and Maon
 Sloan I H 261 272 see Denny
 Slome D 53 56 58 69 see Knight
 Smith A M 381
 Smith H A 156 160 166 178
 Smith F A 411 see Carlson A J and Gibbins
 Smith E B 394 see January
 Smith G K 268 273
 Smith G M 395
 Smith J G 185 200 212 381
 Smith U R 317 329
 Smith V D 194 see Dvorak Carl on H A Lynch Wangenstein and Erickson T C
 Smithson F 255 259
 Smithwick R 339 see White
 Snodgrass T J 330 357
 Snyder J W 380
 Sohn A 375 381 435 443 450
 Solis P P 97 see Cohen L and Levine S
 Sonntag E 311
 Soper H W 295 312
 Souttar H M 225 259 360 365 396 401 419
 Soutter L 116
 Sovana E 399 419
 Soveri V 283
 Spasokukozki M I 384 395
 Sperling L S 27 29 32 34 36 45 47 49 71 see Faine and Wangenstein 97 see Rigler 188 197 198 209 216 see Kremen 300 304 315 451 458 459
 Spindler L A 310 see Crohn Ginsburg Oppenheimer Yunch and Otto
 Spink W S 130 236 250
 Spivack J L 236 448 450
 Spriggs N I 262 264 273
 Stabins S J 49 72 see Morton J J
 Staemmler M 293 310 319
 Stallman J F H 406 419
 Standard S 253
 Starling E H 43 65 132 136 437 441 see Bayless
 Starlinger F 357
 Staunig K 379 see Pfanner
 Staveley A L 342 316
 Steigmann F 448 450 see Singer H A
 Steindl H 446 450
 Stephens V R 413 419
 Stettiner H 284 289
 Steudel 285 289
 Stevens B 59 66 see Bellis Larson W P and Wangenstein
 Steward 268
 Stewart C P 66 see Armour Brown Mitchell Scaris and Dunlap
 Stewart F H 327 332
 Stieda A 275 289
 Stiles H 315 409 419
 Still G F 406 419
 Stone H B 28 38 46 60 66 see Davis D M 72 see Bernheim Whipple and Fior 220 236 285 287 289 365
 Stoner M E 60 68 see Hill 100 110 115 see Hill and O'Loughlin
 Storck A H 197 209 216 323 330 see Rothchild and Ochner
 Stork F 345
 Stromeyer 283
 Strumia M M 253 see McGraw
 Sturm F 458
 Suckow G 66 see Burget Martzloff and Thornton
 Sugito P 46 72
 Sullivan W D 28 70 see Morton J J and Pearse
 Summers J E 292 311 351 357 365
 Sury K V 328 332
 Sussman R M 264 273 see Touroff
 Sutherland G A 407 419
 Swanson P 253 see Klendhof and Witebly
 Sweet G H 263 273 see Robertson C
 Sweet J E 38 58 72 see Peet and Hendrix B M
 Sweet R H 365 384 395
 Swenson P C 96 177 442 see Golden and Leigh
 Swindt J M 9 70 see Montgomery M O
 Szabo K 345
 Tandler J 261 262 273
 Tanner W E 331
 Taylor J 374 380
 Taylor N B 14 40 68 see Greenwood and Haist 72 212 see Weld C H and Harrison G K

- Taylor W 412 419
 Terry W I 324 331 see Mugler
 Theremin I 261 273
 Thiele P 289
 Thomas W 273
 Thompson H I 338 see Judd
 Thorburn W 365
 Thorndike A 419
 Thornton C H 66 see Burget Martz
 loff and Suckow
 Thuss C 132 136 see Blalock and
 Beard
 Tigi R 323 330 438 438 444
 Tischendorf V 267, 273
 Tixier L 395 444 450 see Clavel
 Touroff A S W 264 273 see Sussman
 Treves F 254 260 316 322 329 330
 339 361 376 381 456, 459
 Trotter I B C 453 458
 Truesdale P E 369 378
 Trueta J 126 130
 Trumble H P 339
 Trusler H M 10 33 44 67 see Gatch
 and Ayres 357
 Tung P C 310 see Ngai
 Turner P 450
 Turunen A O I 357
 Tuttle H K 212
 Tuttle H W 255 260
 Tuttle J P 274 289

 U S Bureau of Mines 20 72
 Upon W G 374 379 see Case
 Usadel W 156 178 436 444

 Vallois L 262 273 see de Carrera Gui
 bal and Chaptal
 Van Beuren F T 44 72 185 212 214
 215 see Smith 315
 Vance H M 130
 Vandenberg H J 197 216
 van der Reis 178 see Schembra
 Van Hook W 382
 van Ravenswaay A C 312
 van Zwalenburg C 33 72
 Varco R L 232 236 see Hay and Stev
 ens 285 289
 Vaughan R T 259 see Lewis and Sha
 piro
 Vaughn J W 215 315
 Vick R M 260
 Vidgoff I J 260
 Vital Statistics of U S 4
 Voeckler T 290 310
 Volhard F 59 72
 von Bunge O 15 72
 von Denk W 456 458
 von Hacker 215

 Wade R B 337 see Royle
 Wagner A 316 329
 Wagner G A 436 440 410
 Wahl F 387 395
 Wahren H 56 58 72
 Wakefield F G 67 see Friedell M T
 329 see Vickers P M and Walt
 ers W 426 433 see Mayo C W 450
 see Bergen J A
 Wakeley C P G 329 365 see Atkinson
 Walford W H 285 289
 Walker I J 166 178
 Wallace R H 430 431 see Miller R H
 Walters C W 253
 Walters W 11 72 157 178 204 215
 253 see Hartman H R Hilgore and
 Bollmann 434 see Nygard
 Walther B 332
 Walther H 414
 Walton A J 91 see Moore R M and
 Graham E A. 396 419
 Wangensteen O H 10 17 18 19 20
 27 29 32 34 42 44 46 47 49 51
 52 53 55 71 72 see Chunn Loven
 Loucks Rea Scott H G., Waldron
 Dvorak and Borman 87 91 see
 Paine and Carl on H A 95 96 see
 Borman Gochl and Lynch 97 see
 Lynch 116 119 125 130 143 175
 see Paine 178 197, 214 215 232 236
 242 253 see Hall H Kremen and
 Stevens 255 see Paine 260 see Paine
 Rea Schwyzer and Smith B A
 261 263 279 289 see Rice C O 315
 346 353 357 378 395 419 420 443
 see Paine and Carl on H A 444
 450
 Wanger J J 213 see Hirshfeld and Hy
 man
 Ward R 175 178 414 415
 Wardill W E M 330 420
 Warden R 95
 Warren S 357
 Warvi W N 365 see Orr T G
 Washburn W W 456 458 see Jerrauld
 Watson C M 331
 Watson F C 332
 Watson L F 365
 Wat on P 456 459
 Waugh G E 428 429 431 433
 Waugh J M 434 see Herrell and Crum
 packer
 Webb C H 261 263 273 see Wangen
 steen
 Webb R C 95
 Weber H M 315
 Weeks A 268 273 see Delprat
 Weeks C 395

- Weible R F 305
 Weinberg J A 28 70 see Owings Mc
 Intoh and Stone 378
 Welch W H 292 311
 Weld C B 70 see Taylor N B and
 Harrison
 Wellington J R 397 400 431
 Werchus A 46 59 73
 Werchub I P 395
 Westerman C W J 175 178
 Westhues H 315 see Schmieden
 Whipple A O 68 see Ingwald en 159
 165 178 185 236 245 246 251 315
 see Scudder and Zwemer
 Whipple G H 38 44 46 59 60 73 see
 McQuarrie Stone and Bernheim 176
 215 see Hooper 245 246 251 see
 Robcheit Robbins
 Whitaker I D 452 453 458 see Lem
 berton J
 White J C 10 73 see Fender 240 253
 see Whitelaw Sweet and Hurwitt
 264 339
 White R B 264 267 272 see Judd
 Whitelaw G P 253 see White J C
 Sweet and Hurwitt
 Wiener A S 253
 Wilensky A O 381 see Moscheowitz
 Wilkie D 55 215 342 346 446 450
 455 458
 Williams B W 57 213
 Williamson C S 51 73 see Brown R O
 Wilms M 96 193 213 386 395
 Wil on H 57 68 see Haerem and Dack
 Windle W F 265 271 426 432 see
 Becker Barth and Schulz
 Winn D F 131
 Winterstein O 331
 Wisley A N 431
 Wisner F P 215 see Whipple G H
 Wissing F G 309 see Lowman
 Witebsky E 253 see I lendshof and
 Swanson P
 Wolf W 365
 Wolfer A 322 329 see Lieblein V
 Wolfer J A 215
 Wood G O 400 426
 Wood W Q 292 313
 Wood-Jones F 274 282 289
 Wortman W 291 310 see Braun 383
 384 392 see Borrutau
 Wright S 73
 Wulsten J 458
 Wyes M O 262 273
 Young H H 284 289
 Yunich A M 331 see Crohn
 Zech R L 346
 Zeitlin A 395 433
 Zielke H 370
 Ziemendorff 275 289
 Zillner F 328 332
 Zimmermann I M 445 450
 Zwemer R I 185 214 see Scudder and
 Whipple

SUBJECT INDEX

(The numerals in **bold print** refer to pages in text where the subject matter is discussed at some length)

- Aborption 44 59
 - Avenues of 45
 - In obstruction 44-60
 - Lymphatic absorption 49
 - Influence of intra-enteric pressure on 50
 - Manner and degree of absorption 47
 - Mesenteric vein absorption from obstructed bowel 46 59
 - Of botulinum toxin in closed loops 59
 - Of histamine 45
 - Of potassium ferrocyanide in experimental obstruction 31 35
 - Of strychnine in experimental obstruction 48 63
 - Effect of artery and vein ligations on 56
 - Of strychnine in experimental strangulating obstructions 56
 - Of substances to which normal bowel is permeable 45
 - Of toxic products 1 58 59
 - Of volatile bases in experimental obstruction 59
 - Of water 45
 - Transperitoneal in obstruction 58 169
 - Unresolved problems of in obstruction 58 59
- Abdominal injuries 117
 - Determination of what viscera are injured 118
 - Guiding principles in the management of 117
 - Hemorrhage in 123
 - Treatment of 119 121
- Acetyl beta methylcholine bromide for Hirschsprung's disease 336
- Acute abdominal lesions 117 128
 - Inflammation causing 125
 - Obstructions causing 124
 - Pancreatic necrosis 128
 - Perforation causing 124
- Acute gastric dilatation 343
- Adhesions and bands 347 355
 - Enterolysis for 354
 - Partial enterectomy for 355
 - Prevention of 353
- Adhesive obstruction (see adhesions and bands)
- Partial enterectomy for recurrent obstruction caused by 211
- Adynamic obstruction 435
- Air
 - Mechanism of swallowing 19
 - Lophagostomy to exclude swallowing or aspiration of 17
- Alimentation
 - Influence of state of on mortality from gastric perforations 119
- Alkalosis
 - In obstruction III 11 25
- Amino acids
 - Intravenous administration of 246
- Amniotic fluid
 - Swallowing of by fetus 265 476
- Amyloid disease causing obstruction 291
- Anesthesia 187
 - Effect on fluid loss 244
 - Selection of anesthetic 187
- Anomalies
 - Pyloric stenosis 171
- Antiperistaltic activity of bowel
 - Evidence of 33
 - In obstruction 32
- Anuria
 - Following transfusion 240
- Appendix
 - Secretory capacity of 397
- Arterio-mesenteric obstruction 342
- Ascariasis
 - Causing obstruction 325
- Ascites
 - Diagnosis of 81
- Aseptic decompressive suction enterotomy 209 211
- Aseptic resection 218 234
 - Dealing with epiploic appendages in colonic anastomoses 225
 - Dealing with mesenteric angle 223
 - Implantation of ulfathazole in 232
 - Risks of 234
 - Technique of 221 234
- Aspiration of secretions from pharynx and trachea 237 238
- Assassination
 - Of President Garfield 170
 - Of President McKinley 120
- Atelectasis 241
- Atresia 261 271
 - Duodeno jejunostomy for 271

Bacteria

Absent in thoracic duct in obstruction

51

In lymph nodes in obstruction 51

In peritoneal fluid in strangulation obstruction 57

Lymphatic absorption of in obstruction 50

Multiplication of in obstruction 44

Bands and adhesions 347 355**Barium enema**

Use of in reduction of intussusception 413

Blood

Examination of 89

Increase of non protein nitrogen in 11 100

Leukocytosis in acute abdominal conditions 89

Schilling hemogram 89

Blood loss

In intussusception 411

In operation 240

In strangulating obstructions 51 55

Blood and plasma transfusions 134 238-240**Blood pressure**

Depression of in experimental strangulating obstruction 51 53

In acute abdominal conditions 79 80

Bovine plasma 246**Bowel**

Contractile activity of bowel in obstruction 52

Histology of bowel wall in obstruction 36

Breaking strength

Of normal bowel 27 28

Of obstructed bowel 27 28

Caloric intake

Chart indicating caloric intake 247

Maintenance of during postoperative treatment 248

Requirements 248

Carcinoma of large intestine 298-309**Carcinoma of small intestine 294-298**

Colectomy for 302

(see aseptic resection 224 227 229)

Celiac ganglia

Effect of removal of upon closed loops 41

Chloral hydrate to produce abdominal relaxation 404**Chloride ion**

In plasma and interstitial fluid loss of 12 13

Closed loops 40 60

Absorption of botulinum toxin from 59

Gaseous and fluid content of 16

Intra-enteric pressure in 28

Lymphatic absorption from 50

Neurogenic factor in 40

Perforation of 58

Survival of dogs with 40

Closed resection

(see aseptic resection 218-234)

Use of Petz suturing apparatus 229

Colectomy

(see aseptic resection 224-227 229)

For chronic ulcerative colitis 306

For polyposis 305

Partial colectomy for malignancy 302

Subtotal 307

Colon

Perforation of 30 300 304 328 446

Simple ulcer of 446

Spastic ileus of 446

Technique of resection of 224-227

Compression causing obstruction 340-344

Arterio-mesenteric obstruction 342

Due to pregnancy 340

Congenital hole in mesentery 375**Cyst**

Enteric 290 296 531

Gaseous intestinal 290

Pancreatic 81

Decompression conservative 138 175

(see suction)

Diagnosis

Coordination of clinical and x ray findings 91

Determination as to whether obstruction is complete or incomplete 107

Determination of character of distended loops in obstruction 102

Determination of manner in which bowel is obstructed 107 109

Determining site of location of obstruction 101

Differential 112

Distinguishing between simple and strangulating obstruction 114

Simple obstruction 112

Strangulating obstruction 113

Establishment of 111

General physical findings 99

Identification of type of obstruction 111

Laboratory aids in 100

Making of a 74

Of obstruction 98-115

Questions examiner should put to himself in making a 75

Significance of bowel disturbances in 78

Significance of disturbances of urination 78

- Significance of free air in peritoneal cavity 85
- Significance of hematuria 78
- Significance of history in 75
- Significance of menstrual disturbances in 78
- Significance of nausea and vomiting in 77
- Significance of time element in 110
- Vomiting in obstruction 99
- X-ray observations in 100
- Diaphragmatic hernia 366-370
- Dietary management of high intestinal fistula 202 204
- Distension
 - Absence of in mesenteric thrombosis 453
 - Absence of in strangulating obstruction 115
 - Accumulation of fluid in 16
 - Accumulation of gas in 16
 - Avoidance of in afferent loop in gastrojejunal anastomosis 26
 - Character of 8
 - Control of by suction 138 175
 - Effects of 8 60
 - Necrosis of bowel in 34 35
 - On bowel wall 25
 - On permeability in obstruction 34 35
 - On viability of bowel in obstruction 34 35
 - Summary of 60
 - Systemic effects of 41
 - Upon femoral vein pressure 42
 - Upon intraperitoneal pressure 42
 - Upon plasma loss 41
 - Upon portal vein pressure 43
- Electrolytes 11
 - Loss of 10 11
- Fluids in 8
 - Loss of 10 11
- Gaseous 15
 - Impairs absorption 436
 - In clinical obstruction 104
 - Swallowed air in 17
 - Use of oxygen in the treatment of 16
- Diverticula of small intestine
 - Retention of barium in 321
 - Retention of food in causing obstruction 324
- Duodenal intubation 154-157 161
 - (see suction)
 - History of the use of 174
- Duplications of intestinal canal 431
- Dynamic obstruction 445
- Edema
 - Laryngeal from presence of nasal tube 171 172
 - Pulmonary from high oxygen concentrations 136
- Electrolytes
 - Losses of in obstruction 10
 - Nature of electrolyte losses in obstruction 11 14
- Enteritis 87 219
- Enterectomy
 - For recurrent obstruction 211
- Enterostomostomy 205
 - Remote ill effects from 351
- Enterocolitis 78
 - Diarrhea in 78
- Enterostomy 290 386 431
- Enteroliths causing obstruction 322 325
- Enterotomy 193 198
 - Fluid drainage from 139 140
 - Mortality in 185
 - Necessity of doing the operation aseptically 185
 - Risk of spillage during performance of 193
 - Scoring catheter during 196
 - Technique of 195
- Epileptic hernia 361
- Errors in development of intestine 421
 - (see atresia and congenital stenosis)
- Eosophagostomy
 - In experimental bowel obstruction 17 18 19
 - Survival of dogs with 18 19
- Exomphalos 430
- External intestinal resections 455-457
- Exteriorization of bowel
 - In mesenteric thrombosis 451
- Extrinsic duodenal stenosis
 - (see atresia 261 271)
 - Ladd's operation for 428
 - Wagha Ladd compression syndrome 428 429
- Fistula
 - (see intestinal fistula 202 205)
 - Amount of drainage through ileal 410
- Fluid
 - Administration of fluid while suction in force 172 174
 - Consequences of fluid losses 10
 - Daily turn over of body fluids 9
 - Determining water requirements of patients 243
 - Loss of fluids in obstruction 10
 - Loss of fluids by vomiting 9
 - Loss of gastric juice 8
 - Loss of pancreatic juice 8

- Loss of succus entericus juice 8
 Nature of fluid losses by use of suction 173
 Nature of fluid losses in obstruction 11
 Nature of fluid to be administered 244
 Postoperative administration of 242 245
 Routes for administration of 244
 Food causing obstruction 322
 Foramen of Winslow hernia 370-372
 Foreign bodies causing obstruction 322
 Fowler's position
 Use of 211
 Gallstone obstruction 316 322
 Aseptic removal of gallstone 319 322
 Gas 20
 Analysis of 20
 Free gas in peritoneal cavity 85-92
 Importance of in diagnosis 85 92
 Source of in distension 15
 Tables illustrating gaseous content in obstruction 21 24
 Visualization of bowel on x ray examination 101
 Gastric retention 87
 In obstruction 87 99
 Gastrojejunal obstruction 227 232
 Use of forked catheter in 232
 Glucose solution
 Administration of 134
 Handley's ilocolostomy
 Futility of 439
 Hematoma in bowel due to hemophilia 407
 Hemophilia causing obstruction 407
 Hemorrhage
 From bleeding ulcer 123
 Management of massive 124
 In abdominal injuries 121
 Henoch's purpura causing intussusception 407
 Hernia 358 377
 Beneath limbs of gastrojejunal anastomosis 376
 External 358 364
 Epigastric 361
 Femoral 360
 Inguinal 360
 Littre's 361
 Obturator 362
 Perineal 362
 Supravesical 362
 Internal 366 377
 Congenital hole in the mesentery 375
 Diaphragmatic 366 370
 Foramen of Winslow hernia 370-372
 Interrugmoid 376
 Itra-duodenal 372 375
 Pericecal hernia 377
 Reduction en masse 364
 Hiiccup
 Treatment of 250
 Hirschsprung's disease 333-337
 Acetyl beta methylcholine bromide for 336
 Histology of bowel wall in obstruction 36
 Howship-Romberg sign 362
 Hydration
 Determining status of 243
 Hydrodynamics of negative pressure 145
 Hydrogen sulphide
 In obstruction 24
 Toxicity of 25
 Hyperpotassemia 14
 Depression of by adrenal cortical extract 14
 Question of 14
 Hyperthermia in the treatment of obstruction 353 441
 Hypertonic saline solution
 Use of in paralytic ileus 440
 Ileocecal sphincter and valve 32
 Anatomy of 32
 Influence of in causing diastatic perforation of cecum 30 31
 Influence of upon symptoms of obstruction 26
 Studies of in man 32
 Ileus
 Due to fractured rib 435
 Due to plaster apical cast 435
 Due to retroperitoneal hematoma 435
 Inhibitive 435
 Meconium 327
 Spastic 445
 Ileus duplex 439
 Imperforation of anal canal and rectum 274 287
 Method of determining extent of 279
 Technique of proctoplasty for 284
 Varco glass dilator in treatment of 285
 Vitamin K in the treatment of 270
 Incisions 189 191
 In operations for bowel obstruction 189 192
 Indicanuria 59
 Inflammation 125
 Principles of management of 126
 Use of plaster casts in the treatment of infections of extremities 126
 Inhibition ileus 435-441

- (paralytic)
- Use of Miller Abbott tube in 440
- Intersigmoid hernia 376
- Intestinal anastomosis 221 234
 - (see aseptic anastomosis)
 - Lateral anastomosis in small intestine 228
 - Technique of colonic resection 225
 - Technique of end to-end anastomosis in small intestine 221 225
- Intestinal colic 70
 - Significance of 85 87 98 104 105 109
- Intestinal fistula
 - Dietary management of 202 204
 - MacNaughton scheme for carrying away intestinal secretions 203
 - Protection of skin from digestive juices 205
- Intestine
 - Extensive resections of 455
 - Length of 456
- Intra-enteric pressure 28 29 30
 - Effects of 33
 - Constantly sustained pressure 34
 - In obstruction 26 28 29
 - Large bowel 30
 - Small bowel 29
 - Upon blood flow to bowel 26 33 231
- Intravenous fluids 131 134 172 174 242 248
- Intussusception 396-415
 - Agonal 401
 - Blood loss factor in 411
 - Brown's operation for 411
 - Chronic 405
 - Henoch's purpura causing 407
 - In skunks 397
 - Jejuno-gastric 399
 - Jesset's operation for 411
 - Manner of growth of 401
 - Non operative reduction of 412
 - Of appendix 399
 - Postoperative fever in 412
 - Recurrent 414
 - Spontaneous reduction of 409
 - Surgical treatment of 407-411
 - Types of 399-401
 - X ray findings 405 414
- Jejunostomy feeding mixture 203-204
 - Kirschner's 204
 - Scott Ivy 203
 - Walters-Hartman 204
- Kidney
 - Escape of air around in rupture of retroperitoneal duodenum, 92
- Evidence of renal damage in obstruction 59
- Injury of 118
- Laboratory procedures 88
 - Examination of blood 89
 - Examination of urine 88
 - X ray examinations 89
- Ladd's operation for extrinsic duodenal stenosis 428
- Leucopenia
 - Due to distension 116
 - In experimental obstruction 60 100
- Leukocytosis
 - In obstruction 100
- Littre's hernia 361
- Liver
 - Evidence of liver damage in obstruction 59
 - Liver function tests in obstruction 59
- Lymphatic absorption 49
 - From closed loops 49 50
 - Of dyes in obstruction 49
- Meckel's diverticulum 430
- Meconium causing obstruction 327
- Megacolon 333
- Mesenteric angle
 - Dealing with in end to-end anastomosis 223
- Mesenteric thrombosis and embolism 451-455
 - Occasional absence of distension in 453
- Metabolic disorders simulating obstruction 355
- Miller Abbott tube 161 166
 - (see suction)
 - In the treatment of inhibition ileus 440
 - In the diagnosis of silent intestinal strictures 166
- Mitchell Hunker stitch 218
- Monks Moynihan tube 209
- Morphinism
 - Mistaken for obstruction 354
- Mortality of intestinal obstruction 254 258
 - Influence of age on 257
 - Of conservative decompression 255
- Multiple obstructions 439
- Non rotation of intestine 421-428
 - Operations for relief of 425-428
- Nitrogen
 - Gas in obstruction 21 24
 - Tension of in plasma 135 241
- Nitrogen balance
 - Chart indicating nitrogen intake 247
 - Maintenance of after operation 245-248
 - Use of protein-sparers 246

- Novak's solution 187
 Use of in preparing skin for operation 186
- Obstruction
 Absorption 44
 Arteries of 45
 Blood and plasma transfusions 134
 Classification of 180
 Confusion of sympathetic plexus with obstruction in pelvic colon 111
 Contractile activity of bowel in 32
 Deaths from 4
 Delays in absorption of strychnine in 48
 Diagnosis of 98 115
 (see diagnosis)
 Effects of obstruction 8 13
 High obstruction 8 10 60 61
 Low obstruction 14 19 60
 Evidence of capillary stasis in 33
 Functional 151
 Employment of suction in 151
 Histology of bowel wall in 36
 Hydraulic stress factor in 38
 Influence of ileocecal sphincter and valve upon obstruction 30
 Influence of length of segment 37
 Influence of manner upon effects of 25
 Influence of obstruction upon bowel length 27
 Influence of obstruction upon bowel weight 27 28
 Influence of obstruction upon breaking strength 27 28
 Influence of site upon effects of obstruction 25
 Inhalation of high concentrations of oxygen 135
 Length of survival of dogs with simple obstruction 10 19 23
 Lethal factors in 64
 Mortality of treatment 7
 Neurogenic factor in 40
 Statement of problem 4
 Status of hydration water requirements in 133
 Summary of effects of 60
 Therapy of
 Indirect measures useful in the treatment of 131
 Saline solution 131
- Operation
 (see aseptic resection)
 Aseptic decompressive suction enterotomy 209 211
 Attacking the obstructive mechanism directly 206
 Conduct of 189
 Dealing with distension at 207 211
 Decompressing the obstructed colon 198
 Determining whether bowel is viable 200
 Enterocanastomosis 205
 Exteriorization with establishment of fistula 201
 For simple obstruction 183
 General considerations in the selection of operative procedure 181
 In bowel obstruction 179 211
 Incisions for 189
 Locating the obstruction at 192
 Manner of dealing with strangulated bowel 198
 Mortality of 254 257
 Partial enterectomy for recurrent obstruction 211
 Postoperative complications of 238-242
 Preoperative preparation 185
 Resection and primary anastomosis 206
 Selection of anesthetic 187
 Selection of cases for 179
 The mainstay of therapy 179
 Use of Monks-Moynihan tube in 203 209
- Otitis media from presence of nasal tube 171
- Oxygen
 Inhalation of high concentrations of oxygen in obstruction 135
 Poisoning by 136
 Use of in treatment of distension 16
- Pain 76
 Appendicular colic 76
 Biliary colic 76
 In abdominal colic 76
 In obstruction 98
 Renal colic 76
- Pancreatic necrosis 128
 Diagnosis of 114
- Paraduodenal hernia 372 375
- Paralytic ileus 435-441
 (see inhibition ileus)
- Perforation
 Influence of alimentation upon prognosis of 119
 Items influencing prognosis in perforated ulcer 124
 Of rectum in obstruction 30 31 300 301 328 476
 Of closed intestinal loops 38
 Of duodenal ulcer 92
 Of hollow abdominal viscera 124
 Of stomach 119

- Necessity for operative treatment of 119
- Sealed perforation 114
- Perforation of cecum
 - In carcinoma of colon 300
 - In meconium ileus of new born 328
 - In spastic ileus 446
- Pericecal hernia 377
- Peristalsis
 - Palpable in stricture of bowel 111
 - Visible and palpable 82
- Peritoneum
 - Sensitivity of parietal peritoneum 84
- Peritonitis
 - Unfavorable influence of excursions of diaphragm upon 127
 - Use of sulfanamides in treatment of 127
- Permeability
 - Of capillaries 43 44
 - Of distended intestinal loops III
 - Of intestinal wall to gases 15
- Perussé pressure bottle 34
- Petz suturing apparatus 32 229
- Plasma
 - Content of peritoneal fluid in experimental obstructions 55
 - Loss of in distension 43-44
- Plasma infusions
 - For shock 134 238 240
- Pleuro peritoneal hiatus hernia 367
- Pneumoperitoneum
 - In the treatment of adhesive obstruction 319 354
- Portal blood
 - Of animals dying of obstruction 46-47
- Portal pressure
 - In obstruction 43
- Postoperative complications 238 242
- Postoperative fever in intussusception 412
- Postoperative treatment 237 251
 - (see blood and plasma transfusions 238)
 - Maintenance of caloric and nitrogen balance 245 248
- Potassium
 - In cell fluid 12
 - Level in blood 14
- Pratt's tidal irrigation of rectum 175 439
- Pregnancy causing obstruction 340
- Preoperative preparation 185
- Primary resection 206 218 234
- Procaine block for paralytic ileus 440
- Pulmonary complications
 - Prevention of 247 249
- Pulse
 - In obstruction 79
- Rectal sphonage 174 175
- Reversal of intestine 33
- Richter's hernia 361
- Rigidity
 - In acute abdominal disorders 83
- Röntgenography
 - (see x ray)
- Role of surgeon in suppuration 126
- Rotation of intestine
 - Anomalies of 421-425
 - Embryology of 421
- Saline solution
 - Administrations of while suction is in force 172
 - Effect of in prolonging life of dogs with simple obstruction 26
 - In the treatment of high obstruction 132
 - Value of in high obstructions 132
- Shock
 - Treatment of 238 240
- Skin
 - Preparation of for operation 186
 - Protection from digestive juices 205
- Sodium
 - In plasma and interstitial fluid III
- Sodium chloride balance 132
- Spastic ileus 415-419
 - Confusion with obstruction of pelvic colon 93 446-447
- Spivack's artificial rectum 448
- Stomach
 - Dilatation of 343
 - Volvulus 386
- Strangulating obstruction 51 59
 - Appearance of bowel in 54
 - Bacteriology of peritoneal fluid in 57
 - Blood loss in 51 54 55
 - Conditions simulating 113
 - Determining viability of bowel in 200
 - Diagnosis of 113
 - Effect of loosening ligature in experimental obstructions 51
 - Effect of resection in experimental obstructions 51
 - Exteriorizing devitalized bowel 201
 - Occasional absence of distension in 115 453
 - Operation for 198
 - Primary resection for 206
 - Survival in experimental obstructions 53 54
 - Toxicity of peritoneal fluid in 55
 - Various types of resection in 52
- Status of hydration and water requirements 133
- Strictures causing obstruction 290 293
- Suction 138 175

- Administration of drugs for relief of pain during 167
- After-story of patients treated by 168
- Apparatus to effect 156
- Comparison of fluid and gas removed by suction and siphonage 142
- Complaints of patients relating to use of 170
- Complications of 170 172
- Contraindications to use of 153
- Degree of suction necessary 145
- Determination of fluid loss during use of 160
- Ear marks of successful decompression 166
- Factors suggesting use of 138
- History of 174
- How long should suction be continued 160
- Hydrodynamics of negative pressure 145
- Indications for use of 149
- Lessons learned concerning nature of mechanism of vomiting 170
- Lessons learned concerning toxic factor in simple obstruction 168
- Measures which aid decompression 148
- Miller Abbott tube 161 166
- Complications involving use of 166
- Miscellaneous conditions in which use of suction is indicated 151
- Mortality of 255
- Nature of fluid losses by use of 173
- Necessity for administration of fluid during use of 172
- Necessity for use of 142
- Oral intake of fluid during use of 17
- Passing the duodenal tube 154
- Rationale of conservative decompression 141
- Rectal siphonage 174
- Results of use of in obstruction 167
- Mortality attending use of 255
- Role of conservative decompression in the prevention of obstruction 169
- Schemes to intubate the duodenum 156
- Shortcomings of suction 167
- Technique of employment of 153
- Use of the Miller Abbott tube 161 166
- Other uses of Miller Abbott tube 165
- Use of in postoperative period 348
- Use of stylet in passing 164
- Sulfathiazole
- In intestinal anastomoses 232
- Summer stitch 251 363
- Superiority of slightly superior forces in biological processes 20
- Swallowed air 17
- Sympathectomy
- For Hirschsprung's disease 336
- Temperature
- In abdominal disorders 79
- Tenderness
- In abdominal wall in acute abdominal disorders ■
- In strangulating obstructions 109
- Thorotrast studies of fetal swallowing 426
- Thrombosis
- Prevention of after operation 242
- Thyroid preparations for patients with obstruction 355 449
- Toxemia 57 58 59
- Lessons learned concerning toxic factor in simple obstruction from use of suction 168
- Lethal factors in 64
- Questions of 57 58 59
- Toxic substances in thoracic duct in obstruction 51
- Toxicity
- Of intestinal content 60
- Peritoneal fluid in obstruction 55 56 58
- Tracheotomy for laryngeal edema 17
- Transfusion reactions 240
- Transverse colostomy for acute obstruction of colon 305
- Treatment of acute abdominal lesions 117
- Trendelenburg posture 42
- Effect of upon return of flow of blood from lower extremities in presence of distension 42
- Use of after operation 237 239
- Tumors causing obstruction 209 309
- Benign tumors 290
- Carcinoma of large intestine 298 309
- Carcinoma of small intestine 294 298
- Malignant tumors 293
- Urine
- Examination of 88
- Postoperative retention of 250
- Specific gravity 88
- Varco glass rectal dilator 285
- Venous pressure
- Effect of distension upon 42-43
- Volatile bases in obstruction 59
- Vitamin B in obstruction 355 449
- Volvulus 383 392
- Due to lack of mesenteric fixation 386 426
- In non rotation 425
- Of cecum 385
- Of new born 426

- Necessity for operative treatment of 119
- Sealed perforation 111
- Perforation of cecum
 - In carcinoma of colon 300
 - In meconium ileus of new born 328
 - In spastic ileus 446
- Pericecal hernia 377
- Peritalsia
 - Palpable in stricture of bowel 111
 - Visible and palpable 82
- Peritoneum
 - Sensitivity of parietal peritoneum 84
- Peritonitis
 - Unfavorable influence of excursions of diaphragm upon 127
 - Use of sulfanamides in treatment of 127
- Permeability
 - Of capillaries 43 44
 - Of distended intestinal loops 38
 - Of intestinal wall to gases 15
- Perussé pressure bottle 31
- Petz suturing apparatus 32 229
- Plasma
 - Content of peritoneal fluid in experimental obstructions 55
 - Loss of in distension 43-44
- Plasma infusions
 - For shock 134 238 240
- Pleuro peritoneal hiatus hernia 367
- Pneumoperitoneum
 - In the treatment of adhesive obstruction 319 354
- Portal blood
 - Of animals dying of obstruction 46-47
- Portal pressure
 - In obstruction 43
- Postoperative complications 238 242
- Postoperative fever in intussusception 412
- Postoperative treatment 237 251
 - (see blood and plasma transfusions 238)
 - Maintenance of caloric and nitrogen balance 245 248
- Potassium
 - In cell fluid 12
 - Level in blood 14
- Pratt's tidal irrigation of rectum 175 439
- Pregnancy causing obstruction 340
- Preoperative preparation 185
- Primary resection 206 218 234
- Procaine block for paralytic ileus 440
- Pulmonary complications
 - Prevention of 247 249
- Pulse
 - In obstruction 79
- Rectal siphonage 174 175
- Reversal of intestine 33
- Richter's hernia 361
- Rigidity
 - In acute abdominal disorders 83
- Röntgenography
 - (see x ray)
- Role of surgeon in suppuration 126
- Rotation of intestine
 - Anomalies of 421-425
 - Embryology of 421
- Saline solution
 - Administrations of while suction is in force 172
 - Effect of in prolonging life of dogs with simple obstruction 26
 - In the treatment of high obstructions 132
 - Value of in high obstructions 132
- Shock
 - Treatment of 238-240
- Skin
 - Preparation of for operation 186
 - Protection from digestive juices 205
- Sodium
 - In plasma and interstitial fluid 12
- Sodium chloride balance 132
- Spastic ileus 415-419
 - Confusion with obstruction of pelvic colon 93 446-447
- Spivack's artificial rectum 448
- Stomach
 - Dilatation of 343
 - Volvulus 386
- Strangulating obstruction 51 59
 - Appearance of bowel in 54
 - Bacteriology of peritoneal fluid in 57
 - Blood loss in 51 54 55
 - Conditions simulating 113
 - Determining viability of bowel in 200
 - Diagnosis of 113
 - Effect of loosening ligature in experimental obstructions 51
 - Effect of resection in experimental obstructions 51
 - Externorizing devitalized bowel 201
 - Occasional absence of distension in 115 453
 - Operation for 198
 - Primary resection for 206
 - Survival in experimental obstructions 53 54
 - Toxicity of peritoneal fluid in 55
 - Various types of vessel ligation in 52
- Status of hydration and water requirements 133
- Structures causing obstruction 290 293
- Suction 138 175

THIS BOOK

INTLSTINAL OBSTRUCTIONS

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by

OWEN H WANGFNSTEEN B A , M D , Ph D

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- Of sigmoid flexure 384
- Of small intestine 386
- Of stomach 386
- Prenatal volvulus 426
- Vomiting 77
 - Frequent absence of in colonic obstruction 77 99
 - Lessons concerning mechanism of 170
 - Temporary abatement in intussusception 402
- Wahl's sign
 - In volvulus 387
- Wash board abdomen 296
- Washboard compression syndrome 428
- Weight
 - Postoperative determination of 243
- Welch bacillus
 - Antitoxin for 57
 - In antitoxin obstruction 57
- Worms causing obstruction 325
- X ray 89 101 109
 - (see various types of obstruction)
 - As a diagnostic procedure 89 93
 - Enlargement of intestinal coils in x ray films 106
- Findings
 - In acute gastric dilatation 313
 - In colonic obstruction 101 189 301 302
 - In congenital atresia 265
 - In diaphragmatic hernia 367
 - In extrinsic duodenal stenosis 428
 - In gallstone obstruction 318 319
 - In gastrojejunal intussusception 399
 - In Hirschsprung's disease 334 335
 - In imperforation of anal canal and rectum 279 280
 - In intussusception 405
 - In Meckel's diverticulum 431
 - In mesenteric thrombosis 453
 - In non rotation 427
 - In obstruction during pregnancy 311
 - In para-duodenal hernia 367
 - In paralytic ileus 90 437
 - In perforated ulcer 91 92
 - In recognition of obscure external hernias 362
 - In recurrent volvulus 388
 - In spastic obstruction 447
 - Visualization of external surface of bowel wall in presence of pneumoperitoneum 106

